THE COMPUTER BULLETIN

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Editorial

THE WORD

Many people and organisations have realised that there is a need for a glossary of computing and data processing terms. Three requirements can be distinguished:

1. *Exposition.*—To explain technical terms to the novice, so that he can understand the literature he reads about computers.

2. *Standardisation.*—To ensure that the experts all use the same word for the same thing, or at any rate do not use conflicting, or otherwise bad, terminology.

3. *Translation.*—By explaining the meaning of words, to allow a multi-lingual dictionary to be compiled, giving the equivalents of a term in foreign languages.

What is not realised so clearly is the magnitude and difficulty of the job. It is not very helpful for several organisations to rush different glossaries into print and only confuse the layman. A hastily written explanation of 50 or 100 terms in one speciality in the field, without regard to their use in other specialities, may have slight transient value for the novice, but may later mislead him when he becomes interested in another part of the computer field. It will certainly hinder the achievement of standardised terminology and, however cynical we may be about this as individuals, as a Society we ought not to try to evade our special responsibility of easing the dissemination of information in our subject.

Furthermore automatic data processing impinges on many other subjects which have well-established specialised vocabularies (for example, accountancy and telecommunications). The computer specialist must now invent new terms for concepts which already have accepted names in such subjects.

The requirement, therefore, is for an exhaustive treatment, such as can be given only by numerous specialists in co-operation. As well as a rigorous definition of the meaning of a term, reduced to its essentials for the expert who wishes to conform to standard practice, there is also required an explanation of the meaning in elementary and perhaps less precise language. If the document is not to be much too long it is therefore even more essential than in normal specialist writing to be brief without omitting anything important. In the terms of a well-known saying, this appears to be impossible and the task is therefore taking a little longer.

The British Computer Society has been working on these lines for over eighteen months, although it has not so far published its work. The Society has an experienced Glossary Committee which collaborates with the British Standards Institution Sub-committee on Computer Terminology. This *BSI* sub-committee is divided into several working parties which have been preparing definitions, circulating them for comment, revising them, re-circulating them and so on. Their draft report is due for the summer of 1960 and should cover some 750 terms and concepts ranging from "Access" to "Zeroise". This report will of course be in the form of a *BSI* publication eventually sold to the public.

The *BCS* Glossary Committee under the leadership of Mr. G. C. Toothill is also co-operating on an international scale under the auspices of *UNESCO* to produce an interim multi-lingual dictionary. The British definitions will be translated into four languages—French, German, Spanish, and Russian, and possibly also into Italian and Polish. The translated definitions will then be matched with the correct term in each language by native users of the language who are also expert in automatic data processing. The complementary task, of dealing with definitions written originally in other languages and translated into English, will be performed by the *BCS* which is the internationally recognised co-ordinating body for Britain.

If these projects are not to prove disappointing and inadequate in the realisation, it is clear that there is no possibility of further speeding up of the work. It is also clear that the job can never be finished and the *BCS* contemplates a continuing commitment to revise the work as developments in machines and uses change our terminology. This is a time-consuming project but the *BCS* is now an established society and can think in terms of this time span.

Week-end School

The Association of Certified and Corporate Accountants held a Week-end School on EDP at Queen's College, Oxford, at the beginning of April.

Three papers of particular interest to our members were

I. *Planning and Implementation*—J. W. Kerr and H. A. Y. Dyer.

II. *Financial Control and Auditing Procedures*—R. B. Plank and M. G. Wright.

III. *Problems in Human Relationships*—L. T. W. Sawyer and A. S. Doig.

Discarded Glossary Items

Queue: Method for entering a closed subroutine. If the subroutine is open, no queue is necessary.

Program Debugging: An operation which must be performed on the work of a lousy programmer.

* * *

Riddle: What nursery rhyme is represented by 3·1424159? (Answer on p. 2.)

COMPUTER COMMENT

Challenge to the Boardroom

Mr. O. T. Caminer, Director of Leo Computers Ltd., made some very interesting remarks, at the *BIM* Conference in Glasgow in March, on the approach of top management to computers. He felt that, on the Continent, Directors were more willing to attend courses to acquire the knowledge to appraise computer potentiality. In the UK to spend a week on a course was regarded as quite impossible, and Directors were content to be advised by their staff on what they regarded as "black-magic."

Mr. Caminer made a plea for a real effort to be made by senior executives to understand the possible impact of computers on their organisation. It might be that their mature judgement would see the way ahead more clearly than the officials immersed in the details of computer studies.

* * *

ICT Computer Service for the Midlands

International Computers and Tabulators Ltd., have installed a 1202 electronic computer in their Birmingham service bureau.

Sir Edward Boyle, Bt., Financial Secretary to HM Treasury, in formally inaugurating the machine said that as a Treasury Minister he was fully aware of the enormous importance of data processing. He stressed the pioneering work done by Central Government in office mechanisation and, in particular, the use of electronic computers for data processing. "It is true that for some time past Central Government has been in advance of industry and commerce in the employment of electronic computers for a diversity of work."

Sir Edward particularly commended the design and research effort of *ICT* directed as it was to the development of larger and more versatile computers for which the need was arising.

With the predominance in the Midlands of small- or medium-sized manufacturing organisations who are not in a position to install their own computer, it is anticipated by *ICT* that there will be a particular demand for time on the Birmingham machine for production control jobs, especially "plant loading."

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In the USA

The San Diego State College is organising a conducted tour of EDP installations in operation in California for August 1960. The college students, it appears, can claim credits for attending the tour, for their study course "Office Systems and Automation."

This vacation-work tour lasts two weeks and, to quote from the brochure, "interspersed with the study of automation will be sightseeing trips to places of common interest as well as side trips to Sequoia, Yosemite, a movie studio, and a tour of San Francisco."

Will Cambridge or Manchester please follow?

Answer to riddle on p. 1: "Sing a Song of Sixpence" (that is, 24 in π).

Computing Bureau

English Electric have opened their new Central Computing Bureau, at Kidsgrove near Crewe. The new Computing Bureau has been built as part of a plan to concentrate all the production, research and service activities in connection with computers and control systems under one roof at the Kidsgrove factory. The very considerable work of expansion and re-organisation which this has entailed is now in its final stages.

Two computers have been installed in the main hall of the new Bureau, a DEUCE Mark IIA, with magnetic tape, intended for data processing and the larger-scale problems, and a DEUCE Mark I to deal mainly with scientific and research work. In addition to the accommodation provided for staff and auxiliary equipment, special offices have been built adjoining the bureau for visitors' programming or clerical work.

The Bureau is conveniently situated at a central point at Kidsgrove to cover industrial, commercial and scientific computing requirements over the whole of the Midlands.

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ICT Graduate Fellowship

ICT are offering from September 1960 a Graduate Fellowship tenable at the Massachusetts Institute of Technology, Cambridge, USA. The recipient will undertake Graduate Study and Research in a subject associated with electronic digital computers and their use.

Living expenses to the extent of \$250 per month and travelling expenses to and from Cambridge, USA, will be paid by *ICT*, together with tuition fees.

It is expected that the Fellowship will cover two academic years, but its duration will be reviewed after the first year, and a third year is possible if this appears advisable.

No restriction will be placed upon the work of the accepted candidate within the broad outline of the subject laid down. He will, however, be expected to undertake to return to the United Kingdom for not less than 12 months after the completion of his Fellowship.

* * *

Dr. Leo Esaki

Dr. Leo Esaki, discoverer of the Esaki or tunnel diode, has joined *IBM* as a resident consultant. He will work with the *IBM* Semiconductor Research Department at Poughkeepsie, New York, where much of the Company's diode investigation work is carried out.

The tunnel diode was first reported by Dr. Esaki in *The Physical Review* of 1958.

Interest in the Esaki diode has been intensified because it has many desirable characteristics not common to other semiconductor devices such as transistors. It is capable of handling extremely high counting rates, a natural advantage for a component in high-speed computers. In addition, it can operate from near absolute zero to several hundred degrees centigrade, and has remarkable resistance to radiation damage.

PROBLEMS IN INSTALLING DATA PROCESSING EQUIPMENT IN BUSINESS

by H. W. Gearing

(*This paper is based on a talk given to* The British Computer Society, *Glasgow Branch, at a meeting held on* 1 *February* 1960.)

Introduction

When I accepted the invitation of the Glasgow Branch Committee, I had just returned from the UNESCO Conference on computers in Paris. As often happens after one has attended a computer conference, I felt happy about the scientific work, but concerned by the absence of any papers there on business applications. Business users fared better the following week at Cambridge; but why is it that progress in the business sphere seems to be so slow? Are the problems of application so much greater than those of logical design and engineering? They may be, because we are dealing part of the time with people, not with solid-state devices like magnetic cores and transistors!

The Problems, or Some of Them

The problems of installing data processing equipment in business fall into a dozen or more distinct classes, such as:

(1) Establishing an economic justification for acquiring the equipment and setting up a data processing centre, the running cost of which, including depreciation and maintenance, may be of the order of £200 per day, or higher.

(2) Obtaining an appreciation at a senior management level, by busy people, of what a computer might do, and also what it cannot do.

(3) Planning for the types of data which may be collected, at the feasibility-study stage.

(4) Training programmers and the initial programming work.

(5) Informing other parts of the organisation of progress in the survey and feasibility study of particular applications.

(6) The selection of the appropriate equipment for the job.

After the computer has been ordered, there follows work on:

(7) Selection of site, preparation of the computer room.

(8) Forms and procedures for collection of data.

(9) Program development and testing.

(10) Transfer of existing files to new media.

(11) Taking over not too slowly, nor too quickly.

(12) Operator training and documentation of new routine.

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1. *Economic Justification*

Many American companies in 1955/56 had justified the purchase of computers because the expected computer costs would be less than the punched-card routines which the computers were to replace. In making a comparison between American and British experiences, we recognise that American industry supplies its employees with a higher level of capital equipment per person employed, than we do. I think we *use* it more. This is illustrated by my experience in visits to American punched-card installations, where I found large amounts of rented equipment, used for part of the month only. With the aid of this equipment, the capacity of which was adequate to meet peak loads at the beginning of the month, and male operators for the sorters and tabulators, who were prepared to work shifts, we were told that American management received its statistical reports very rapidly at month-end. In contrast, we often find in Britain smaller installations, planned to deal with statistical work after routine accountancy, payrolls, etc. This method, which may not be common to all British companies, has led to smaller installations than in the States, but a higher intensity of usage throughout the month.

It is fairly clear that a computer can give selective information more quickly than can other forms of equipment, and if properly programmed, it can take the slog out of jobs such as stock control, payrolls, etc. But where, as in the case of The Metal Box Company Ltd., the units to be served cover a wide area, it is not easy to make accurate estimates of the saving that will accrue in routine work at each decentralised point.

2. *Management Appreciation*

On the question of understanding what a computer might do, and what it cannot do, the approach of many companies may have been stimulated initially by proposals made by the machine manufacturers. Others who have realised that they ought themselves to know most about their own business have appointed staff to study the possibilities. We have gained an appreciation of what a computer might do in our organisation, firstly from our contacts with manufacturers, users of computers in scientific work, other businesses, visits to various laboratories, and conferences, and secondly, from trials within our own organisation.

When a company uses complicated equipment in its factories, it employs mechanical engineers or production engineers to help in its design and layout. These people draw fully on the recommendations of the equipment manufacturers, but in due course make substantial contributions to the design and layout of the various

pieces of plant involved. It should not, in my view, be otherwise in offices, now that the degree of potential mechanisation is comparable to that in the factories. Large organisations will be able to employ someone full time on this work, whereas smaller companies will depend on the recommendations of firms of consultants who are able to offer this service (de Paula 1959). The stimulus of contact with scientific computer users is available to all those who join the British Computer Society; the apparent need for this communication between the different professions and types of user was the main reason which led me to work with others for its formation.

In a business, we have first to define what information management requires. It is possible to classify management information into various categories, for example, that required for planning, that required for day-to-day operation, and that required for record purposes, such as records of turnover with important customers. How much is required at each level of management, in regular reports, and how much must be held ready for immediate retrieval for answers to questions, is a problem that will be exercising the minds of those who intend to apply their computer to management information.

Leo Computers Limited, the pioneers in the application of computers to business data processing, have made significant progress in this work; information is available about this in published reports on their stock-control procedures for their London area tea shops, leaf-tea buying, etc. (P.E.P. July 1957).

3. *Data Feasibility*

Before we can provide better and more sensitive information to management by central processing on a computer, we need to bring a great deal more detailed information to the centre. I should, perhaps, say more detailed *and* more sensitive information. Those of us who have graduated to working on the preparation of consolidated reports for top management, through earlier experience in professional and factory accounting offices, will have recognised the advance in management's control of financial results obtained by the introduction of monthly financial accounts. We have there recognised the importance of obtaining reasonably accurate and consistent monthly stock valuations, including work-in-progress, etc., if the monthly accounts are to be accurate. In order that we may comment upon and explain any unexpected changes in the monthly figures, we need also to have a fully detailed analysis of expenditure, material consumed, and other costs, and of running time and idle time of machinery. Where this work is built up manually, the junior clerk in workshop and office acquires a basic knowledge of the company's business. There is considerable editing of information before it reaches the analysis sheet, on which the accounting journal entries are based.

In the computer era, we shall need to collect, in many applications, information at weekly or daily intervals from outlying offices and factories. The design of the collection procedure and the classification and coding of data has got to be simple enough for the collection to be made rapidly; but the coding system will need to be detailed enough to provide, when necessary in the central tabulation, that detailed information which was previously transmitted through the various levels of clerical editing and processing. The design of coding systems, which achieve the correct balance between economy in the cost of collection and the giving of detailed information at the centre, is a major problem for a widespread organisation.

4. *Training of programmers*

On the training of programmers, I have already said something in my paper at Cambridge last year (Gearing 1959). There is, in my opinion, no reason why any company that can keep trained staff should be caught out in future with a computer installed, and programming work not finished. Any company that is thinking of the possibility of installing a computer within the next 10 years, should set about training some of its clerical staff for programming work now, despite the fact that the need for programmers for the 1960's generation of computers will be less than for those of the 1950's.

I believe that professional organisations, such as the Chartered Institute of Secretaries and others, which provide standards of training for clerical staff, should include elementary programming in their syllabuses. Sixth forms in schools should also do some programming. The *way* that the work is done in the office is more important to the great majority of staff than the detailed background of its legal framework. Any office manager must, of course, have a basic training in company and mercantile law, in order to appreciate *why* things are done in a certain way, when and where contracts become enforceable, etc. Office organisation and procedure is however a very difficult subject to teach. There were very few text books on the subject. Because of this dearth, a group of large British companies formed the O. and M. Council which has recently published a book entitled "Organisation and Methods" under the editorship of Mr. G. E. Milward (Milward 1959).

In the early computers, the programmer has had to give attention not only to the sequence of calculations and data processing within the machine, but also to the problems of scaling and overflow. These are catered for automatically in the automatic programming facilities to which I refer later. It is expected that the 1960 generation of machines will have advanced facilities for automatic programming. Nevertheless, to get the best out of them, a knowledge of basic computer programming is desirable.

5. *Informing other parts of the organisation*

On the problem of informing others of progress and trials, my division began by issuing quarterly reports to heads of other divisions, summarising the experience which had been gained elsewhere, and the principal details of the new machines that were becoming available.

This technique was useful up to about the end of 1956, mainly to offset the naïvity of the press.

More recently we have made some substantial progress in keeping others informed of what we are doing, by carrying out the programming of model jobs, some of which have not previously been attempted on the scale we expect to tackle them with the computer. We started off in 1957/58 by trying to program these jobs in full machine code, and at one time we had the ambition of doing each job with more than one computer, in order to compare computer speeds, etc. This proved to be very time-consuming, and we found that the second and subsequent programs were always more efficient that the first, due to the experience gained. With the publication in the autumn of 1958 of the Ferranti Pegasus Autocode (Clark and Felton 1958) we began to do work in hired-computer time, for statistical quality control; by writing programs for statistical jobs such as an analysis of variance in autocode, we could, in the course of a few days, satisfy the quality control statisticians that the computer had a useful service to render. Some of these programs were subsequently written in machine code.

At first we hesitated to apply autocode to business data processing problems, in view of the vast amount of information that would have to be punched into paper tape. Much of these data were already available in punched cards in our Powers Section. In the latter part of 1958 and early 1959, we had worked on programs to process this information on the Pegasus/Pluto computer at the Powers–Samas laboratories at Whyteleaf in Surrey. Good progress was made in programming, but we were testing our program at the same time as the engineers were developing new input and output equipment on the machine; this coupled with distance meant that the development of our programs took considerable time. All this provided most useful experience for our programming staff.

About 4 months ago, however, we decided to approach an important clerical job involving data from a sales analysis by products, using the Pegasus autocode and the facilities of the London Computer Centre of Ferranti Limited, the *NRDC* Computer at the Northampton College of Advanced Technology (London) and the computer installed at the *BISRA* Laboratories. Thanks to the help of Ferranti Limited, in punching up large quantities of data after a concentrated effort of our staff in collecting data for several years on to special forms from Powers tabulations, we have recently made some rapid progress.

The discussions which we have had with other departments on the results of this work have done much to bring out the speed and full possibilities of the computer. The cost of the trial will be less than if we had tried to write full scale programs on the lines that we were doing about a year ago. The autocode program developed as a result of such exercises will form the basis of final flow charts for the real job.

The job we are doing by autocode is not the final job in all its detail. We are flow-charting this, but the autocode program will provide a parallel operation to the manual routines, so that we can gain experience for the detailed job, on which a great deal of programming effort will be needed.

6. *Selection of Equipment*

There is much choice. A survey of what was available appeared in *The Computer Bulletin* in 1958–59 (Hooper and Gearing 1959) and a further note in *The Computer Journal* last October. We have deal to with questions such as:

(*a*) compatability with existing equipment.
(*b*) random-access memories, or sequential files.
(*c*) on-line or off-line working of peripheral equipment.
(*d*) how big must the various storage levels be for our work.

Some of these questions can be approached by trial programming and hired time, such as I have indicated.

One has to invest much time on programming to find out what is really needed. I covered this point fairly fully in an earlier paper (Gearing 1958).

7. *Site selection and preparation*

Some computers seem to have been sited in odd places. Many American companies wanted them to be a show piece.

One must leave room for expansion. The room should be convenient of access to those who use the machinery but not a corridor. A most important consideration is to have reasonable facilities for making tea and coffee during shift operation! Few people will be working much overtime.

The more technical considerations have to be settled with the computer manufacturers and architects and you need air conditioning, if you are going to have magnetic tapes.

8. *Forms and procedure*

The collection of data on forms convenient both to the originators of the data and the punchers is helped if there is an established *O & M* division in the company. Draft forms prepared locally on office duplicating equipment can be experimented with during the trial programming stage.

The data required to trigger the computer should use sizes, descriptions and other digital information as used in the factory. Such quaint units as the basis box (area of tinplate) with a radix of 112 sheets to the box, can be handled as easily by a binary machine, as can any other radix.

If, for example, we prepare advices in advance for our despatch operation, are we satisfied that the document is not processed until the physical delivery has taken place? Let us use the opportunity for easier recording, at the point of origin, if possible. What is the minimum amount of information that we need to put on delivery notes, requisitions, etc., to avoid any ambiguity in the understanding by the recipients of the materials being handled and to ensure correct processing of the document by the

computer? There is considerable scope for training of staff at the lower levels in order to achieve economies in this work of recording.

Let us also remember that of all the various processes of statistical methods, that of data collection is the most expensive part on any survey: the document must be designed to be suitable and convenient to those who are making the initial recording. It seems to me that mark-sensing schemes fall down in the face of this requirement because they are too cumbersome, but no doubt many of you will hold other views.

9. *Program development and testing*

I was greatly encouraged during a recent colloquium at Cambridge University when Mr. George Felton said that a program was never fully tested. In the course of time, data combinations will arise which have not been foreseen by the programmer and one needs to have a careful note of the limitations of the program, both as to the number of storage locations available and the size of the numbers that can go into each. Careful filing of working papers at each stage of program development and the willingness to devote time to cross-referencing one's working papers will make it easier for those facts to be recognised among teams of programmers. Ingenuity in programming is only effective in so far as one can communicate it to other members of the team: if one keeps the working papers in a form that someone else might understand, we ourselves may hope to understand them again when we have to go back to the job and make alterations in a few years' time!

If Felton's remarks are true for mathematical work, they are even more true in business, because additional lines of manufacture and new business will tend constantly to alter the range of calculations to be dealt with. The number of variable parameters required in business programs is very great.

10. *Transfer of existing files to new media*

Some of the difficulties here were mentioned in the papers given at the Business Computer Symposium at Olympia in December 1958 which have recently been published by Pitman. I have in mind particularly, the papers by Mr. K. W. Shang of A.B. Datacentralen (*Trygg-Fylgia Insurance Company Group*), Sweden and Mr. D. G. Pedder (*Radio Rentals Limited*). A lot of ingenious people have devoted time to designing equipment to read print. If only there were some equipment to read embossed type from present machine plates, then one job, the process of conversion of existing files of customers' names and addresses to the computer, would be easier.

11. *Take over not too slowly, nor too quickly*

It is necessary to have a period of parallel operation which it is suggested should be confined to a section of the work, which contains as many complications as possible. Full scale parallel operation is too expensive, but one must avoid trying to go over to the computer too quickly, and repeating the mistake that was made in the 1930's by at least one local-government authority, trying to go to punched cards too quickly.

12. *Operator training and documentation of new routines*

Companies which have accounting machine installations, particularly if their offices are located away from the normal centres of training of clerical staff, have already faced this problem, and may have a nucleus of machine-trained operators, some of whom can be trained for working with the computer. I think that all users of office equipment should adopt a policy of recruiting junior staff for training.

As each job is moved from the experimental stage to the operational stage, all aspects of the procedure should be documented. This together with the need for careful indexing of magnetic tape files, etc., makes it important to have someone to act as a librarian at a fairly early stage in the computer installation: this person should be someone already well acquainted with the company's business, for example, a senior statistical clerk whose work is being taken over by the computer, might be a suitable candidate for this.

Conclusion

Any views I have expressed must be taken as being my own and may not necessarily be shared by my colleagues. They have been built up as a result of the stimulation of discussions with those colleagues and other users. I hope that although I may not have provided the answer to many of the problems I have mentioned, I may have given some explanation to the scientific members of this Branch why computer applications are often so slow in becoming effective in business.

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THE ACCURACY OF DATA PREPARATION

by G. H. Hinds

Introduction

During the discussions on the reliability of digital computer systems, recently held at the *Institution of Electrical Engineers* under the aegis of the *British Group for Computation and Automatic Control*, the notion of the economics of accuracy was never far from the surface. Here are some of the ideas that were expressed or implied: the accuracy which is important to the user is that of the whole data processing chain; this is more valuable in some jobs than in others; the accuracy of any one link in the chain can generally be improved, but only at a cost; and the accuracy of the chain as a whole can be most economically improved by concentrating on the least accurate link. These ideas cannot be exploited without knowing quantitatively the standards of accuracy being achieved by present accepted methods.

It had been suspected that the preparation of the input data, as punched cards or tape, was one of the important sources of mistakes, but firm quantitative data were difficult to find. To provide this information, a number of conventional punched-card offices agreed to survey their own activities and to reply to a questionnaire; the opportunity was taken to include in this some questions on the nature of the mistakes which were made. Replies to this questionnaire have now been received from five different offices, and the results have been analysed. The offices concerned used many different types of equipment and dealt with a wide variety of types of work. Interesting data were also received from one office, giving similar information about the marking of dual-purpose cards for mark sensing.

Frequency of Card Punching Errors

Data from four different card-punching offices are summarised and analysed in Table 1. These offices are in four different organisations, and cover a variety of classes of work: in three of the offices, records were analysed daily for a week; in the fourth, very short runs were punched each day for four main classes of work, and the analysis is by class of work and not by daily performance. In the great majority of cases the data to be copied were in manuscript (mainly in pencil), so that it has been impossible to determine whether there is a real degradation in accuracy when punching from manuscript rather than from typescript records. The total number of cards analysed is about 55,000.

In every case cards were punched and verified; where the punch operator knew that she had made a mistake, the card was removed and repunched, and does not appear in the record. For three groups of cards, covering more than half of the total, an independent check (by control totals or visual scrutiny of the final output) provided a measure of the proportion of mistakes which passed undetected through the process of verification.

The two main conclusions are that, *in the offices concerned:*

(*a*) The proportion of punched cards which contain errors detected by the verifier is about 2%. This is generally as expected.

(*b*) The proportion of verified cards, which contain errors which are subsequently detected, is about 2 per 10,000. This is much better than at least some preconceived ideas.

The following incidental points also emerge:

(i) The proportion of spoilt cards increases with the number of columns punched in each card, but this increase is less than would be expected.

(ii) The day-to-day variability is high.

(iii) There is an indication that there may be an increase in error rate, when the work consists of short runs at mixed tasks.

The Nature of Punching Errors

(*a*) That part of the questionnaire relating to the nature of punching errors asked for 100 spoilt cards in each office to be selected at random from those detected by verification, and asked that records be kept of certain specified errors (those which are most likely to be detected by error-detecting codes) and for a description of other troublesome mistakes. The data from these replies are summarised in Table 2, Section (*a*) which includes *all* classes of errors reported.

(*b*) The proportion of unspecified errors varies widely (between 10% and 79% of spoilt cards): this makes it difficult to compare the relative frequency of the specified errors; the latter have therefore been extracted, scaled up to 100%, and tabulated separately in Section (*b*) of Table 2.

(*c*) *Specified Errors.* This section indicates clearly that, of all the errors which are detectable by good error-detecting codes, single transcription (punching a wrong character in one column) is the most frequent and single transposition (interchanging the numbers in two adjacent columns) is also frequent. Double transpositions (interchanging the numbers in columns next but one to

each other) and combinations of two errors in one card, also occur with sufficient frequency to justify precautions.

(*d*) *Unspecified Errors.* Many of the unspecified errors brought to light were due to incorrect adjustment or use of the machine, i.e. carriage sticking, misfeeding of cards, transposition of plugs, failure to hit the shift key sufficiently hard. Errors directly ascribable to the operator include punching in the wrong column, or in the wrong field, or in the wrong position in a field: these errors can all be detected in a computer by tests for double punching, blank columns and inadmissible columns; such tests can be programmed and the present results suggest that, where punched cards are used as computer-data input, this should always be done.

Cards for Mark Sensing

These records were taken in a pay office, where dual-purpose Hollerith cards were prepared from forms completed in manuscript: the office was divided into four sections, all doing the same class of work, and records were taken in each section on one day in each of three weeks; the results are summarised in Table 3.

The proportion of errors disclosed by a subsequent independent check varies considerably from week to week and still more from section to section, extreme values being one in 400 and one in 2,500 spoilt cards: an average figure for this office is about one in 650. The number of substandard cards is more uniform, and indicates that about one in 200 cards will be rejected: this rate is higher but is less objectionable as these cards, although they will slow down the subsequent processing, will not lead to wrong answers.

Error Index

For some purposes there may be a need for an error index to express the order of magnitude of the error rate. It is suggested that, if a representative value of the error rate is one mistake in n characters, then the characteristic of $\log_{10}n$ is defined as the "error index." For example, the above error rate of 2 spoilt cards per 10,000 verified cards, with an average of 50 columns punched per card, corresponds to one wrong character to about 250,000 characters, or an error index of 5; similarly, the mistakes in marking for mark-sensing, at one spoilt card in 650, and 12 columns per card, gives an error index of 3.

Table 1—FREQUENCY OF CARD PUNCHING ERRORS

Proportion of Spoilt Cards Detected (a) by Verification and (b) by Independent Check

Office	A					B					
Equipment	Powers-40 automatic key punch					Hollerith					
Nature of work ..	Wages analysis					Wages		Stores			
Source documents ..	Pencil entries					Pencil entries (few typescript)					
Day of week	*M.*	*Tu.*	*W.*	*Th.*	*F.*	*M.*	*Tu.*	*Tu.*	*W.*	*Th.*	*F.*
Number of columns punched	31	31	31	31	18	72	72	64	64	64	64
Number of cards punched	640	3050	2570	2460	2600	11687	6302	1967	3935	4802	4184
Total	8720				2600	17989		14888			
Number of cards with errors detected by verification	11	76	71	44	73	234	121	40	76	51	101
Total	202				73	355		268			
Per cent spoilt cards ..	1·7	2·5	2·8	1·8	2·9	2·0	1·9	2·0	1·9	1·1	2·4
Total	2·2				2·9	2·0		1·8			
Nature of independent check	Control totals					Control totals		None			
Verified cards with errors detected	Nil					5		—			
Per 10,000	Nil					2·8		—			

Office	C					D			
Equipment	Hollerith skip punch and mechanical vertifier					Hollerith Punch Visual. Hollerith. Visual			
Nature of work ..	Paybills, etc.								
Source documents ..	Manuscript (various)					*Pensions*	*Repair Records*	*Accident Records*	*Staff Records*
Day of week	*M.*	*Tu.*	*W.*	*Th.*	*F.*				
Number of columns punched	20	10	17	40	7	20	40	35	54
Number of cards punched	8454	269	957	121	714	286	603	175	557
Total	10515					—	—	—	—
Number of cards with errors detected by verification	115	1	29	5	5	1	13	12	33
Total	155					—	—	—	—
Per cent spoilt cards ..	1·3	0·4	3·0	4·1	0·7	0·3	2·1	6·8	6·0
Total	1·5								
Nature of independent check	Visual scrutiny of output					None			
Verified cards with errors detected	2					—			
Per 10,000	2·0					—			

Table 2—NATURE OF PUNCHING ERRORS

Number of Errors in each Class per Hundred Spoilt Cards

Office	A	B	C	D	E		
		(a) All errors					
Cards with one error:							
One transcription error	83	70	45	69	6		
One transposition error	2	3	1	16	7		
One double transposition error	—	1	—	5	1		
Cards with two errors:—							
Two transcription errors	4	2	2	—	2		
One transcription and one transposition	—	—	—	—	3		
Other combinations	—	—	—	—	2		
Errors not described above	11	24	52	10	79		
Total spoilt cards	100	100	100	100	100		
		(b) Transcription and transposition errors only					
Cards with one error:						*Average*	*Average excluding E*
One transcription error	94	92	94	76	29	78	90
One transposition error	2	4	2	18	32	11	6
One double transposition error	—	1	—	6	5	2	2
Cards with two errors:							
Two transcription errors	4	3	4	—	10	4	2
One transcription and one transposition	—	—	—	—	14	3	—
Other combinations	—	—	—	—	10	2	—
Total	100	100	100	100	100	100	100

Note: A "transcription" error occurs when a wrong number is punched in its own column; a "single transposition" when digits in two adjacent columns are interchanged; and a "double transposition" when interchange occurs in columns which are next but one to each other.

Table 3—PROPORTION OF SPOILT DUAL-PURPOSE CARDS (Mark Sensing)

Section	*No. of marking staff*	*No. of cards marked*	*Week*	*Sub-standard cards rejected by reproducer* %	*Mean* %	*Mean deviation*	*Errors disclosed by post-machine check* %	*Mean* %	*Mean deviation*
1	38	19,800	1 2 3	0·81 0·35 0·41	0·58	0·19	0·040 0·035 0·046	0·040	0·003
2	32	7,000	1 2 3	0·83 0·60 0·21	0·55	0·22	0·128 0·114 0·171	0·137	0·022
3	33	21,500	1 2 3	0·37 0·37 0·43	0·39	0·03	0·214 0·153 0·195	0·187	0·022
4	37	22,700	1 2 3	0·37 0·29 0·39	0·35	0·04	0·229 0·246 0·246	0·240	0·007
		Overall mean:			0·47			0·151	

DEVELOPMENT OF EDP UNITS

by John J. Finelli

This article is based on a paper given at a meeting of the Society on Wednesday, 24 *February* 1960, *in the Lecture Hall of the* National Cash Register Company, *Marylebone Road, London, N.W.*1, *with Mr. R. L. Michaelson in the Chair.*

Mr. Finelli is a Fellow of the Society of Actuaries *of America. He was in England by the invitation of the* British Institute of Actuaries.

"*In* 1928, *Mr. Finelli joined the* Metropolitan Life Insurance Company *of New York, the largest life assurance company in the world. He joined as a junior and is now the Third Vice-President in charge of their unit, responsible for their electronic development processing installation. The Company accepted delivery of its first* UNIVAC *installation in* 1954. *Now there are four* UNIVACS *and some punched-card machines. Mr. Finelli spoke extemporarily with five years of practical experience, a basis which made his talk unique in the history of this Society.*"

I would like to add to the Chairman's remarks one other thing: I came unprepared for this meeting. My primary purpose was to address the Institute of Actuaries. As a result of the discussion which occurred at the presentation of my paper, however, I have been given some indication of the questions which are of major interest to you here; I shall make a few remarks about them and then ask you to put further questions to me. I find myself somewhat handicapped. Having lived with electronic problems for some ten years, I have lost some of the feel for the things people just at the beginning would like to know about. You will have to guide me in that respect.

Mr. Michaelson said we installed our first UNIVAC in 1954. That was the first magnetic-tape machine to be used in our business. Looking back at the various early occurrences with that computer, one thing comes to mind. Our computer was delivered in April 1954, but the high-speed printer was not. We proceeded to do what amounted to almost two years' work for certain jobs in an actuarial unit which has to do with producing business statistics. The results were recorded on magnetic tape and were held in that form for a period of about six months. By October of the year when the printer was delivered we had developed a great deal of information on tape which could not be seen and could not be checked. Commencing in October, we printed out that information. There were some errors in the results, of course, but the thing which was significant about it was that after converting the invisible answers into some kind of readable form, examining them and finding the causes of errors, we were able, between 15 October and the following 15 January, to repeat what amounted to about a full year's work. We got it done with improved programs and with accurate results in time to meet our annual statement requirements for the year. This, on the first magnetic tape undertaking, represented a bit of gratification, if not a degree of satisfaction. You can fly blind a little in the computer field, and not always land on your head.

Now, some few years later, we have reviewed our experience to find aspects of the work which seem significant with respect to future operations. Some of these I can discuss with you today.

One is that on a fairly sizeable operation being handled with punched-card equipment of the tabulator type (this excludes the IBM 650 computer but includes the IBM 604 and earlier punched-card calculators), the introduction of magnetic tape doing essentially the same type of thing as was done before—not a fundamental review and replanning of the problem—produced for us about 50% reduction in operating cost (i.e., new procedures operate at 50% of the cost of the punched-card operation displaced). In an area of work where there is a fair amount of re-engineering done (in the sense that one is looking into the area of work and examining whether one needs as many records, and to what extent the number of files and record cards could be reduced, and so on), we would be somewhat disappointed if we did not produce an overall result from using a magnetic tape system that reduces the operation to 25% or less of its former cost. Both comments are made on the assumption that there is a central data processing unit which has a large and efficient processing machine available. So far, it looks to us as though the greater the capacity of the equipment used, the lower the costs tend to be, provided there is a sufficiently large workload.

Someone recently referred to my Company as "king-sized." In that respect, we are fortunate in that we have yet to feel the need to find more work in order to keep computers gainfully employed. We have operated three UNIVACS 24 hours per day, six days a week (we have now cut it down to 20 hours a day for reasons other than those dealing with the need for computer time). The computers perform every day except Sunday, and we try to keep them alive all the time. On Sunday, the power is still on, but at reduced voltages. We have recently acquired a fourth UNIVAC.

I have gathered the impression that in general there is a good deal of concern about the cost of developing procedures, programming, testing computer methods, and that sort of thing. So far, our own experience indicates that development of new procedures for new computers is an expensive undertaking. However, it may not be more expensive, relatively, than the corresponding costs for developing procedure changes in clerical and punched-card operations. Changing procedures of any kind is an expensive undertaking, especially when the changes are extensive (i.e., where they involve operations to be performed by a large number of people).

Also, the larger items of expense that are involved seem to stem from the necessity to set up a 'perfect' set of records to start with. Clerks generally 'interpret' minor defects and correct mentally for them. Practically speaking a computer cannot do so. To eliminate what you might call unimportant defects which grew up over a period of years

was a very difficult matter. The whole area of setting up the initial records and purifying them is very expensive and accounts for a large proportion of the development and installation costs which have been associated with our operation.

Another item of importance was the relatively high cost which attaches to what we call "defining the problem." This is the problem of setting down on paper precisely what has been done in all its detail over the past few years (the current procedures); and re-casting such procedures into the form which we would like to apply when using electronic equipment. The process runs somewhat as follows: A person is delegated to study procedures in a given area of work. He sits down with the division manager currently responsible for the work, or others, to discuss the problem and try to chart some of the major things to be done. For building a program for the computer, he wants to know the significance of the actions, the calculations and the operations involved, and what work manuals exist. He must also sit down with the many clerical people, each of whom give him as much of the story as they can. As a result of several conferences there comes a point when he believes he has a reasonably comprehensive statement of the work to be done. When it is programmed, however, he often learns that there are many additional details to reflect before the development is completed. The need for better techniques and for definitive and precise language for describing procedures has been very much emphasised in our minds by our experience.

We are glad to note a lot of progress in that area. Many are trying to develop patterns; standard type ways of describing processes. Automatic programming with which you are all familiar, is also beginning to supply a more promising outlook for the future.

Of course, the most important matter to be established is that of obtaining a good return for the investments made in electronic procedures. To give some figures concerning economics, I have a few notes which are taken from a talk which my boss, Mr. York, recently prepared for another purpose. These are based on actual figures of savings for completed projects, and estimates of savings on not yet completed projects.

We can make a comparison between the net annual expense saving on the one hand and, on the other, the investment in the machines, and the investment in procedure development. We can think of the net annual saving as the difference between the cost of the old procedures displaced and the cost of the new electronic methods, excluding amortisation.

It appears from the work on which the first three UNIVACS are employed that for every dollar saved from the old procedures displaced, new electronic procedures costing about 30 cents were necessary, producing a net annual saving of about 70 cents. To produce this net annual saving, however, it was necessary to invest two dollars in initial costs (about one-half for the equipment, and one-half in development costs); thus, we should realise a return of about 70 cents per year for every two dollars invested, or about 35% for interest and for amortisation.

Another item to be called to your attention is the improvement in the magnetic tape machines now offered, as compared with earlier models. One of my people gave me, just before I left New York, an analysis of various tape systems we have been studying along with estimates of unit costs for certain operations. Before quoting some of these figures, I must ask you to keep in mind (*a*) that the second generation computers I will refer to are machines deliverable in late 1960 and in 1961, and (*b*) that the figures are highly theoretical estimates which assume full-time use of the equipment.

To set a basis to measure from punched-card operations might be the first ones to deal with. Talking about a 12-digit sort of 1,000 eighty-column cards, we estimate that this would cost about 90 cents per 1,000, with punched-card sorting machinery. With the magnetic tape UNIVAC II, we now have in use, the corresponding cost would be $1.64. (You will note that I did not indicate any size for the sorting key. As you probably appreciate, with magnetic tape equipment, the size of the sorting key is not a governing element in sorting costs.) With a second generation tape system, sorting a corresponding set of records, 1,000 records, the cost would run at 40 cents. Based on the figure of $1.64, we have often said that sorting is an important operation to avoid in designing tape procedures. It still is an important operation to avoid because it is one of the operations which tape computers do at relatively higher cost than they can do other operations. However, there has been a great change for the better in the cost of sorting records on magnetic tape.

Another rather significant figure to think of in this regard, is the cost of merging files. For merging eight files of 80 or 100 characters per item on the file, 1,000 such items (that is, an aggregate of 1,000 records spread over eight files), if the records are in punched-card form, the cost of merging would come to about 54 cents with punched-card machinery. If the records are on magnetic tape, the cost of merging would be about 33 cents with the UNIVAC II, and about 12 cents with a solid state second generation machine.

The last set of unit costs I will mention deal with updating. In a process where you have 1,000 records and are assuming 10% will be changed to some extent (for example, substituting a new fact for an old one), with a punched-card file and with punched-card equipment, it has been estimated that it would cost $1.12 to substitute a changed card for the old card in the file. With a file on magnetic tape, using the computer we now have, it would cost about $0.36 to produce a new file with the changed information. With a second generation computer, the corresponding cost would be about $0·07.

As you think of these figures I ask you to keep in mind that when we are talking about a second generation computer we are talking about a pretty expensive machine and that these are consumed time costs (i.e., it is assumed that the computer is gainfully employed every bit of the scheduled time, so the figures do not reflect the cost of idle time; the cost rises when the machine is not fully employed).

As an indication of trend, I should also report that we had just about finished our analysis of second generation computers when we learned that a supplier was offering a third generation computer. The third generation machine was a much higher priced assembly of solid state components consisting of two computers and a processor, all interconnected. The processor, is in effect, another computer which is used almost exclusively to direct and control the flow of information. The objective of the assembly was to make available a very high speed machine capable of doing many different operations simultaneously, and also capable of reading and writing on tape at very high speeds.

We briefly analysed it before I left and came to the conclusion that with a machine of that capacity we could think in terms of having eight or nine different jobs going on concurrently, each of which could be completed in a very short elapsed time. We think we have learned a great deal

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about such a machine, but the question we now have to consider is: are we better off moving in the direction of one very large assembly of many components, depending heavily on its effective operation for very long periods of time without long failures or interruptions, or would we be better advised to use two or three of a smaller system which would give us more back stop protection. It is a tough question for us to deal with. Our experience has brought out five or six occasions in the past when one of the computers we had was non-operative for eight, ten, and even more hours. However, the arguments put forward as to the degree of protection that exists in the newer computers to guard against long non-use periods are very strong. Operating dependability is one of those things which must be looked into very carefully.

I mentioned the higher speed reading and writing on tape. I should give some indication of what I mean by higher speed. Our UNIVAC II speeds are 25,000 characters per second. One of the second generation computers we are studying, the H-800, operates at a character reading rate of close to 74,000 per second and can handle several units at this rate simultaneously whereas UNIVAC tape units can move only one at a time for reading and writing.

In connection with our studies as to when we should acquire another computer and which one it should be, we have been making inquiries as to the probable future increases in tape reading speeds. From the indications received to date, speeds of at least 200,000 characters per second appear likely. However, just when equipment capable of such higher speeds is deliverable, in sufficiently proved-out form, we are not entirely sure of. Hence, we are again faced with the question of whether to wait a little longer for machines of higher capacity which have not yet been fully developed, in the sense that such speeds have not been field-tested. In considering this question, we are very mindful of the fact that a review of our operations made some seven months or so ago indicated that a delay of one year in introducing equipment of the magnetic tape kind now available is about equivalent to a loss of more than one million dollars in the form of lost savings which would otherwise be realised. With a potential of that size, one cannot wait too long for improved models.

I seem to have gone on a little longer than I intended with the preliminary remarks, so I will call your attention to a paper which I think is good. It is the February 1960 issue of the magazine called *Datamation*, and it refers to a design of a machine called a polymorphic data processing system. As I see it, the point the author tries to make is that we are moving into a period in which users might well think in terms of installing a computing plant; basic assemblies of components built in modular form which would permit the user to expand his capacity by adding more modules. By being careful to accept modules which have enough capacity built in them to permit adaptation of improvements likely to come in the future, capacity growth can be provided for. It is an interesting design which calls for a large amount of automatic control of the scheduling of the work to be done as well as the performance of the work itself.

So far as the significance of these new developments goes, it seems to me that we are reaching a point at which magnetic tape equipment (if you look at the cost, size, and capacity of the smallest unit as well as the largest) is beginning to cover a pretty wide spread. With writing speeds from 10,000 characters per second, up to several hundred thousand, which some of us regard as likely to come, there is a pretty wide spectrum within which to fit our data processing loads. Our general feeling is that the cost at the smallest end of the scale is probably still a few years from coming down, but it is likely to come down. This, plus the fact that various arrangements for time-sharing use of magnetic tape computers are coming into existence, seems to be moving such equipment into the cost range which will make it economic for small companies as well as large ones.

I believe that is all I need to cover in opening up the discussion. I shall do my best with any questions you care to bring up.

General Discussion

The CHAIRMAN, declaring the discussion open, welcomed visitors to the meeting and invited them to take part in the discussion.

Mr. R. G. HITCHCOCK: Would Mr. Finelli tell us whether commercial autocodes are in any degree in widespread use in the States and whether he makes any use of them and, if so, what he thinks of them?

Mr. FINELLI: I suppose you mean the auto-programming-compiling systems. Is that right? ("Yes"). We have had in use since late 1954 what we have come to call the Metropolitan Compiler. It is a compiler which permits the programmer to designate which one or more of the subroutines stored on a library tape should be brought together and how they are to fit into the final program. With such instructions the computer will extract pieces from a library tape and combine them with other specially coded pieces to produce a final program. It has been a very valuable aid for well over five years, and has been used routinely on both UNIVAC I and UNIVAC II. We are now preparing to use an automatic routine which should permit a programmer (and possibly even someone not highly skilled in programming) to express the program by the use of English statements in a form the machine can read and act on. We have had two men at work on it for several months and expect that before 1960 is out we shall have a practical system for preparing programs automatically from specifications expressed by English words and phrases. One of the suppliers has already produced an English language compiler which we have tested and believe to be 20% or more inefficient. We are not using it at present to avoid increasing our running time too much, but I have been told there are seven companies using it extensively.

The answer to your question is "Yes." It is very important as a method of economising on computer development work. Many others are now using compiler techniques and other programming aids. The matter of developing codes for a computer program, however, is not the biggest part of the job. Any assembler can come into play only after you have made up your mind as to what the program should do. Developing the specifications is the more difficult part of the job.

Mr. G. FELTON: I should like to ask whether in view of the remarkable figures he has referred to for magnetic-tape equipment now being developed, Mr. Finelli sees any future in what are commonly called random access stores, disc stores, and devices of that nature?

Mr. FINELLI: I studied statements of capacity of random-access devices; performance figures I know nothing about. In two airline companies which have already introduced computer systems which tie in wire communications to remote ticket agencies, random access continues to be important as a matter of service. Reservations service is handled in a

matter of a few seconds. Serial searches when the volume of data is large cannot achieve such speeds. Whether such speedy access to information will be of use in the life insurance office type of operation we have, I am not sure. We have one company in the States which is giving its policyholders service in its district offices by having precalculated many of the figures they need in order to pay certain amounts of cash on request to the policyholder. Whether that rapidity of service is worthwhile at the costs involved, we are not sure. If it is, we shall probably find ourselves interested in random access; if not serial searching would be quite adequate. We believe we would be able to run our entire policyholder account records which, with us, runs to some 40 million accounts, at least twice a day, and not strain the newer equipment too much—if we thought it useful to do so.

It is also interesting to note that practically all suppliers in the field are talking of faster serial searching and also of greater volume of random access. At the proper economic levels, both techniques would be attractive.

Mr. R. W. Jones: I would like to ask Mr. Finelli to comment on getting fresh information into the system, whether he prefers Unitypers to card-to-tape converters; does he have any views on the future development of input equipment?

Mr. Finelli: First I should make the comment that the area which seems to be the one in which we have seen the smallest amount of new development is the area of initial input. This question of the Unityper, which is a typewriter which types direct on to tape, versus punching a card first and then going on to another machine, is one which has had much consideration in the last two years. There are two smaller companies who believe that it is more economical to type directly on to tape. I have tried to analyse that view and see the rationale for it, but at the present time I remain convinced that from the economic point of view it is less expensive to punch cards and then convert the cards to a reel of magnetic tape. Economy seems to favour the two-step procedure rather than direct recording.

Mr. Brooke: What is the status of the EDP installation manager within the Company and what is the nature of the organisation? It strikes me as significant that the Third Vice-President should be in charge of this operation. How did it happen?

Mr. Finelli: I am indebted to a good friend of mine, Mr. William Phillips, for having become attracted to machine applications of mathematics. He wrote a paper in 1936 which some of us who read it thought was one of the best things we saw at that time. I still re-read it every so often.

Somewhere around 1938, or thereabouts, we were faced with the task of developing a new set of dividends for ordinary insurance without enough people to do the job. We thought it might be a good time to try our hand at some machine calculations and machine data processing. In those days we had nothing more than the IBM 601 multiplier, but after the usual trials and tribulations of a first-time kind of thing, we managed to get our dividends calculated. That set the stage for subsequent events which turned out to be the calculation of new premium rates and values a few years later, and other series of calculations made by punched cards. I happened to be in charge of the dividend operation at the time. It seems that no matter where else I was assigned in the Company there was a task which could be helped by a bit of machine calculating or processing. Along about 1948, the Society of Actuaries in the States appointed a Committee to look into electronic machines and I was appointed to help it do so. I was also helping with Company investigations. It was a part-time job initially, but it grew into a pretty full-time undertaking in a few years. The fact that I became a company officer probably did not have very much to do with the selection for this particular assignment, but the fact that I had been interested in machine processing possibly did. As you move into the larger scale equipment, where the information to be processed embraces the operation of many different departments, certainly the total company view of the whole must become applied as early as possible in the development process. Some of us who had the opportunity to work in many areas had that advantage. For a company starting new I would recommend that the leader should be someone pretty high in the ranks who has a pretty good view of the company operations as a unified whole.

Mr. H. B. Burdeau: Could you give me an idea of how long the investigation of the system and procedures takes before the computer is installed? What part of the overall savings attributed to the installation of the computer was due to the system investigation, that is, the elimination of duplicate records and simplification of clerical procedures?

Mr. Finelli: That has occurred to several of us in our Company, and we have made a few attempts which have been quite unsatisfactory. The thing we cannot measure is whether a particular saving is attributable to the system ideas or the computer facilities involved. If new system ideas and a computer are brought in, in combination, that would yield a big saving. The best I can do is with the figures I gave you before. We have analysed our agents' weekly registers project which represented purely a translation of the same procedure from a punched-card routine to a magnetic tape routine and that I believe shows a cost reduction currently of somewhere about 50% (i.e., the same block of work is running at about 50% of its previous cost). We are expecting to get a little more than that out of it. With regard to a mortgage job, where we handle more than 350,000 investment accounts—dealing with correspondents in the field making these investments for us—in keeping records, and verifying payments made and so on, we find that a block of such work seems to be operating somewhere about 17% of former cost and we expect that will come down to nearer 12%. System ideas are reflected in the mortgage job and I feel certain that without these ideas we would not approach anywhere near that 17%, but to state how much is attributable to the ideas and how much to the machine cannot be done as far as I am concerned.. Some of us believe the new system ideas would not have been practical without tape machinery. The two aspects are too interdependent to permit separation.

Mr. E. J. R. Hewitt: The efficiency of a particular job depends to some extent on the time taken to correct a fault. Would Mr. Finelli tell us how long should be the maximum re-run time?

Mr. Finelli: I wish I knew! The maximum re-run time is a problem and all I can do is to tell you of the changes in attitude which occurred with us. We started with UNIVAC in 1954 with the idea that we did not have to write into our programs what we call re-run procedures, provided we could keep the work in small units which would not run more than two hours. We soon learned that two hours was too long a time for the machines to operate effectively without some kind of interruption and no one wants to go back to the beginning after two hours. Within a year we cut it down to one hour and that has since come down to ½ hour as an objective. We think we should be in a position to come to a check point (a restart point) of not more than ½ hour away;

that may be a little optimistic, I do not know. However, we have whenever possible built in re-run procedures which require going back only to the beginning of the reel in process for re-run purposes. We try to stay within a ½ hour rule where we have not built in re-run procedures.

Mr. NEWSOME: I think Mr. Finelli mentioned 20 hours a day running at the moment. Could he give some indication of how much of that time is spent in routine maintenance and an indication of the distribution of the time between faults?

Mr. FINELLI: The routine maintenance time amounts to 2–6 hours per day per computer, or a total of upwards of 30 hours of preventative maintenance per week for each computer. We were rather fortunate dealing with a supplier who was both understanding and co-operative in many respects and we have been able to make arrangements with him under which the major portion of that routine maintenance is performed outside scheduled hours, some on Saturdays and Sundays.

On the incidence of stoppage, it is very hard for us to give you any information because within the past four years we introduced many component modifications on three of the machines, so that we have no basis to give you significant experience figures. However, we expect about five stoppages per day per machine. If stoppage lasts longer than 10 minutes or so, the manager is alerted to supervise the work and to make any schedule modifications. The stoppages with the three machines we think are frequent, the time necessary to correct the fault is usually pretty small. I believe our experience would yield practically no useful indication of the time it would take with a second generation machine, they are so entirely different in that respect. Most of the faults, are faults with the tape writing or reading mechanism; the tape will not accept a signal or will not read the signal transmitted to it for a variety of reasons, sometimes due to characteristics of the tape itself.

Dr. F. YATES: Could Mr. Finelli give us any views on the question of large versus small computers? I am thinking particularly of the case where one firm has not enough work for one large computer but may have enough work for a small one. Would it be an advantage to combine with several other organisations to run a larger computer?

Mr. FINELLI: I am not a very good person to judge something like that, having been with a large company so long, but I have discussed it with several people. So far as economics go we are pretty convinced that the bigger and more flexible the machine the higher the purchase cost, but the lower the unit cost. From the point of view of pure economics the tendency would be towards using large machines. I have also had conversations with people wondering why, in view of the fact that a computer is mainly an elaborate switching network (like a telephone network), suppliers do not supply a computer service under a dial type control.

There is a centre in New England where three fire insurance companies have pooled to acquire a large-scale computer and to the best of my knowledge it is working out reasonably well. My own feeling is that there will probably be a movement in the direction of supplying a hire computer service, because through a computer service facility very small companies would obtain the advantage of low operating costs. It is significant that a firm like *RCA* has set up service offices in New York and is doing work of that sort for several brokers on a contract basis. The trends seem to be in that direction.

Mr. R. G. WADSWORTH: You have mentioned that 6 million live accounts are filed on magnetic tape. As all your policyholders cannot be regimented into paying exactly on time, you must have a problem of input discipline in respect of the premium credits. In view of the vast number of accounts, how do you organise the daily input to ensure that only the minimum of necessary magnetic tape is run each day? With premiums being paid out of time-sequence, do you build up a suspense file of all credits first?

Mr. FINELLI: We set up a buffer store of the accounts receivable when we bill our policyholders. One of the subsidiary outputs of the billing process is a punched card which is sent to the collection point. Payment may come in next week, in five weeks, or not at all. Whenever the premium is paid, that punched card is used as evidence of the payment. That is sent to the Home Office, it is converted to tape and the tape is sorted so as to be in the same arrangement as the tape file of premiums due. Then the Payments Tape goes through the serial job of matching payment against the due amount on file. For people who pay out of sequence, or for different amounts than expected, the computer puts them out as probable errors. These are investigated and corrected where need be. One of the correctives applied in cases where a payment has been skipped, is to hold a later payment until one previously due has been made. There are two points at which payment irregularities are detected—the collection point when the punched card is located and at the Home Office via the tape procedure.

Mr. NASH: I have been worried since the second question on the preparation of data. Taking a normal commercial application where there is a large amount of input/output and a small calculation, I have found that to keep a machine on the air required the efforts of 24 punched-card machine operators for about 20 hours a day. If one looks at the speeds here, one wonders how many operators one needs to keep the machine on the air at the speed you are talking about, and whether you take in the costs of the operators when you calculate the costs, showing the costs of punched-card methods as against first and second generation computers.

Mr. FINELLI: The cost of preparing punched cards is not in the unit costs I mentioned earlier. Those were only processing costs. I have trouble in dealing with 24 punched card operators to a computer. Take the one operation I have talked about, dealing with premiums. The information is on the tape to start with, the tape itself makes the punched card which later becomes input. We get input from a tape operation, not from a card punching operation. This involves 18 million punched cards per year. That is quite a sizeable number of punched cards that are generated not key punched. Your question is a systems question and is very difficult to deal with without more information.

Mr. NASH: The particular application I was talking about is a special inventory control problem; I do not know how near realisation it now is. We found that we could store centrally on magnetic tape the static data as such, but that we would get a large volume of variable data, relating to stocks and movement of stocks. It was estimated that it would require 24 operators to keep this up-to-date and provide the input information to be put into the machine to be processed to produce the results. I feel that you also must have met somewhere the same form of problem; what worries me is, at the speed that you are talking about, the number of operators you would require to get the machines on the air for 24 hours a day, which would make data preparation an expensive part of the system.

Mr. FINELLI: The punch operator is not a very expensive part of the operation I mentioned, but I wonder whether the use of the computer is a function of the number of punched card inputs involved in any system. In our situation we have to have cards punched for every policy issued, for a policy which requests surrender, to file a change of address, and so on, and we have about 70 people concerned with punch operations, but the handling of these items which represent activity initiated by customer (policyholder) is a small percentage of the total processing which the computer itself does. It runs through a whole series of operations, keeping the file up-to-date, selecting items on which activity has to be undertaken and so on. So far as our operation is concerned, there is very little correlation between volume of keyed input information and computer time required. The time required depends more on what the computer is asked to do with information already on tape than it does on new information being punched. (We actually are using somewhat more than 70 in current operation because we are adding new information into the files as part of the installation work.)

Mr. HARWELL: I understand that in some installations there is a good deal of breakage of magnetic tapes. How many files do you keep back, as history, and what is the approximate size of the library of magnetic tapes?

Mr. FINELLI: Breakage? You mean the tape actually breaking into two parts? We have had practically none of that. We use metallic tape and breakage is not a problem, but a certain amount of damage and wear in operation is a problem. Figures which we took out recently show that we have to replace tape at the rate of 1% per year, considering the five years during which it has been used. We have some 18,000 reels of metallic tape in our reservoir, our library as you call it. For protection of the basic record we keep three generations of tape; the file as it is in the current run, the file as it was prior to the current updating—these two are in the office all the time—and a third generation is sent away from the office to a basic record repository, outside the city limits, as a security measure. That substitutes for a prior safeguarding of records procedure which called for micro-filming.

Mr. N. A. MILLER: What do you do about operating conditions with regard to dirt, and so on, in the handling of tapes?

Mr. FINELLI: We originally prided ourselves on not introducing many dust control conditions. We had a few visitors who asked why we did not have this control, whilst most of our competitors did. At the time we said we did not need it with this kind of metallic tape and we did not. But we modernised our equipment later and doubled the density of recording. The dust which was not a problem before became a problem after the change. We have now installed a few dust filtering devices to keep the room cleaner and we have purchased a tape cleaner to wipe off the dust and lubricate the tape, but we have not done anything else. We are having a certain amount of loss on account of dust on tape. If and when we modernise again, I am sure we shall be more careful about the dust control aspects.

Mr. C. FREEDMAN: I understood you to say that tapes last at least five years but that only 1% of tapes have to be replaced each year. Would you expand on this, please?

On a second point, you gave earlier a history of your re-run procedures; could you give us a similar history of checking of information written on tapes? Do you still follow your original procedures or has experience led to changes?

Mr. FINELLI: Your first question had to do with the 1% replacement of tapes in five years. That represents this, that with our first installation in 1954 we bought 5,000 reels of metallic tape. We recently reviewed the history of that particular 5,000 reels and we find that a little less than 5% of the tapes are no longer in use, either because of damage or scalloping on the edges, and that develops for us about 1% a year which seems to be the rate at which the tape is deteriorating. What the ultimate effect will be I do not know, but that is the best we can do with limited experience.

As to the kind of thing you need to carry, to make sure that your answers come out right, we apply generally what is called an item-count check. Each reel of tape has a total of the number of records it carries. When it is run, the number of records written on a new reel is compared with that on the old reel and checked, after adjusting for known deletions or additions. This is an automatic thing the computer is asked to do. We have introduced another test, which is becoming quite standard. In addition to carrying the item count of every tape, we carry an inventory count of the number of policies carried forward, making sure that they come out the same number which went into a particular operation.

Mr. M. G. SHELMERDINE: How much parallel running is done before a new program is regarded as fit for operational purposes? Do you completely rewrite sections of the program which are found to be unacceptable because they do not comply with the original specification or prove to be susceptible to operating errors?

Mr. FINELLI: How much parallel running is done? A lot. And what do you do if there is trouble? We try to study it, but we do not study as often as we should. We run a job for three cycles in parallel with the current method before we break into use without the current method. It is not too unusual to find that some mistake has been made in the design six months afterwards, because of certain types of situations which do not come up frequently. If the programmer who did the job is with us he can deal with it, if he is not it is a headache for somebody else, but after a week or two he usually sees his way through and can make the correction. One of the big values of automatic programming techniques is that it makes it easier to reconstruct somebody else's work. We had one situation which was rather interesting. On a rather important job we decided not to employ parallel runs as a prove-out. As it turned out we had about six months of some of the most difficult correction periods I have been through. It was a payroll program and people like to be paid on time, so corrections had to be made under pressure. People are most unpredictable; for example, one person decided within the same week first that he wanted vacation and later that he wanted to put his vacation off a month or so. He went to the pay office and told them, but we could not do anything to put the vacation operation in reverse, because our program had not anticipated such a rapid change of mind. It took six months or so to correct all the gaps in that program and it taught us a lesson "Do not take it off without a good solid parallel operation."

Mr. PAUL: Is it not a problem for a computer user to change to another computer having regard for the amount of tape he has built up in his library, particularly in your Company, where you have magnetic tape? It might be as well to keep to one system, because of the basic cost of the tape which you hold, which could be several hundred thousand dollars now, apart from the time which would be required to reprogram the work.

Mr. Finelli: The question is, is it a problem; the answer is yes. We have been very concerned about it. We have quite a large tape inventory. We have a number of suppliers making suggestions as to the equipment we should use. So far each one has indicated that he would supply with the new equipment either a tape writing unit which will permit the continued use of metallic tape, or a translating device which will permit us to convert from one to the other. We do not know what we are going to do yet. It is significant that our supplier arranged for tape handling units on the UNIVAC II which should be capable of reading both metallic tape and Mylar tape. If we are going to have different tape in the future, to cut our losses on metallic tape, we would like to know now and move over to the tape of the future, but we do not know what that is yet.

Mr. C. E. Twell: My question relates to what you said in answer to a previous question, that provided the particular programmer were available, things were not too bad, and if he were not, you were likely to be in trouble. I refer also to the question of automatic programming with the UNIVAC Flowmatic system. If you had made wider use of this system, would it have been easier to iron out an error, when the original programmer was not available?

Mr. Finelli: I agree. We wrote in our contract with the supplier that we wanted them to submit with the equipment an automatic system of the Flowmatic type. We used it for one or two programs under test, but found it rather inefficient from the point of view of running time involved. The supplier, being the supplier of many customers, must think in terms of developing a general system to be used by us and others. As a result many general programs are produced, not programs specially designed for the insurance business. Had we used Flowmatic, and lived with it, we would have had less difficulty in correcting programs; it does that very nicely. But we would have paid too much for it in terms of running costs. We expect to reach the same goal with a system we are designing for ourselves. Ability to change readily is an advantage of automatic programming.

Mr. A. R. Harwood: When you set up your initial records, was their purification an entirely clerical process or were you able to use your computer, and if so, to what extent?

Mr. Finelli: We did a great deal of the purification with the computer. We set up our records originally from certain punched cards; they were more than 10 years out of date in some cases. By association of one file with another we were able to bring them up to date. You know the nature of your business, you know the particular type of benefit ceasing at age 65, for example, and you test every case to make sure a man of 65 has no such benefit, but you are not surprised to find cases where the records show he has. A correction becomes indicated. That type of purification you get done on the computer; you automatically correct for it. In the course of our purification we used the computer to recalculate every premium we were charging policyholders and made sure that they agreed with the premium actually being used for billing—to check the record. In addition, we determined a particular year as being the year on which we would recheck whatever dividend was paid, to make sure all the facts were right. In that way we had evidence of possible error which had to be examined; some of them turned out to be simple rounding errors where you rounded up instead of down-turning. These were analysed by the computer. We did that on the computer but what remained had to be pure clerical analysis. I think less than 4% of the whole involved some kind of look-up in other records for correction purposes.

Mr. A. H. Beaven: I would like to ask something about the qualifications of people doing the investigation and the programming of some of the jobs already done, what age they were, and whether there were any qualified actuaries on the team?

Mr. Finelli: The computer operation in our Company really started in the Actuarial Division and the investigation was undertaken by actuaries. The first investigations and programs were undertaken by a group of about six people, which included two Fellows of our American Society and four students. These four students have remained amongst the most skilled people we have in the programming and investigation phases. They were all originally aspiring to be actuaries. I was very fortunate indeed to get them, and in this area of work they turned out to be quite valuable.

Then, what we did was to ask the manager in charge of other departments to put forward their promising people. We made a selection by interview trying to pick particular characteristics, and asked them and many others to take a series of aptitude tests, not as a selection medium but to check our own thinking and to eliminate obvious misfits. This turned out fairly well. Our limitation was that we should recruit in the Company from among people in a certain salary level—a level at which most occupants were up pretty high in the age bracket.

We have now got 30 to 31 people who are programmers, about a dozen are highly qualified, really expert programmers. The others are good programmers, satisfactory but not exceptional.

Mr. G. J. Mills: If you are doing monthly reports, do you expect to replace 1% of your tapes annually? If, however, you are running the tapes through daily or twice daily, will you not find yourselves with an enormous tape bill?

Mr. Finelli: We hope not; I do not know about tape wear, but one of the conditions of the tape system we are now considering is that there should be less riding and wear on the tape. The experience I have given is on our original battery of tapes, which received more punishment. We collect experience on each reel and find it has been used over and over again so that it is effective experience from that point of view. Unless some of the representations received and observations we have made turn out to be very unsound, we expect that under the new writing techniques, when there is a more polished head to work with, there should be much less wear. It is also significant to know that damage to the tape, which causes it to be ruled out, is not so much wear in the writing area as it is a certain curling which occurs at the edges and works its way in; it seems to be more a function of the tape guides, which may not permit precise winding without edge distortion.

We recognise, of course, that daily running increases exposure to damage, but we think it will remain within acceptable limits.

Mr. F. S. Ellis: What proportion of the running time of the computer do you use for the mathematical jobs in insurance business, the calculation of premiums, and so forth, and what proportion for file maintenance and the routine running of the business?

Mr. Finelli: The mathematical job, so called, the sequence of purely arithmetical operations is such a small part, less than 1%, I would not put a figure on it. Basically, our equipment is used as data processing equipment practically all the time. Most of the work is file-keeping, classification

sorting and selection, and totalling; there is very little mathematical work. We have had occasions to do what used to be a lot of mathematical work in the past—for example, when we calculated new premium rates and made other calculations of an actuarial nature—but these have turned out to be such small size jobs on the computer that we make many more than we ever did before without throwing a significant burden on the computer.

In reply to a question by a Mr. DUKE, which was inaudible to the recorder, Mr. FINELLI said: We have developed systems of priorities; some work needs to be done at certain times each week, other jobs have a monthly cycle which can be moved around a little. The programmer who needs computer time, which conflicts with a priority, finds it gets a little difficult at times, but not unreasonably so. We are fortunate in a way. Our supplier is located across the street from us. There is a computer there, which we can use when badly needed. This has helped.

The CHAIRMAN acknowledged the kindness of the *National Cash Register Company* in allowing the use of their hall for the meeting; he also thanked the *Institute of Actuaries* for inviting Mr. Finelli to this country; thirdly, he would like to thank the *Metropolitan Life Company* for permitting Mr. Finelli to give such a frank and valuable exposition of what had been done and what it was hoped to do in the future. Fourthly, he thanked Mr. Finelli for coming at short notice to address the meeting and for answering so many questions with so much courtesy and helpfulness.

A MIDSUMMER NIGHT'S DREAM

1961 *EDP System, Electronic Logician With Labiodental Interpretive Squeaker*

(*Confidential to BCS Members*)

Type

Electrosonic digital.

Input Media

1. Plastic corrugated cards—double sided with edge-notched control positions.
2. Discs—black vynil, round hole.
3. 6-band magnetic film—33⅓ mm—outside sprockets with sprag interruption.
4. Embroidered nylon tape (sub-contracted by Cash's).

Input Mechanisms for above Media

1. U.A.K.D. (un-automatic krinkle detector).
2. R.D.S.C. (Revolutionary disc to sound converter)—3 speeds (33, 45 and 78 r.p.m.) with double-headed reading needle for interstage working.
3. Magnetic film reader with random access by 6 inciter lamps *en echelon*.
4. Singer machine with hemming foot (electrically or treadle operated).

Output Media

1. Parchment and invisible ink.
2. Corrugated plastic cards.
3. Sellotape.

Output Mechanisms

1. Quill output extendable to pentograph working with optional ink-wells.
2. U.A.K.P. (unwanted auxiliary kinematic pulse units with double banked encephalographs). This machine has one receiver for each half of the card. Prolific reproducer attachment is an optional extra.
3. On-line Winkle's Eye for automatic up-dating.
4. Labiodental interpretive squeaker for programmed errors.

Optional Extra

Continuous Centrifugal Cement Mixer and three perforated solvex bags of cement to turn the machine into a solid state device when the market trend requires it.

Buffers

Hydraulic spring-loaded double cryo-cells in crossed diagonalised arrays (unbevelled version).

Storage

1. Copper kettle drum (para. 2, 3 4/3) speed controlled by R.D.S.C. for permanent storage.
2. L.I.A.R.S. (loose intermediate abacoid random selectors) for more or less immediate access.
3. E.A.R.S. (erratic acoustic record stores).

Arithmetic Unit

This unit consists of 3¾ registers connected to the B.A.N.T.U.S. (Babbage abaco-numeric transfer units) by circular serrated mechanical devices.

Operations

Add. All other operations have to be sub-routined.

Order Code

Overwhelmingly powerful.

Examples

Instr.	*Disc.*	*Column Duodenaliser*	*Function*	*Phrendivisor*
0	30	53·792	I	22·5
1	1	1	MP	1

Instruction 0	zeroises the net pay store.
Instruction 1	multiplies *a* by *b* divides by *c* and gives the cube root of the result correct to 5 decimal places. The answer is automatically output through all media.

Technical Information

P.R.F.	1 bicycle per second.
Number base.	Very. (Dodecahedral coded decimal or binary).
Mode	Fashionable (cereal-parallel).
Word length.	$12^3 + 1^3$ parity. Alpha 3½ characters per word.
Word time.	Depends on length of word.
Instructions.	See Appendix A.
Weight	50 short stone, on average.
Dimensions.	12 ft. × 3 in. × 6 in. × 9 in.

TOWARDS A COMMON PROGRAMMING LANGUAGE (4)

Some further notes on the use of subroutines

Our last issue (*The Computer Bulletin*, Vol. 3, Nos. 5–6, p. 87) contained an article prepared by the Research Committee on the Standardisation of Scientific Programming Notation, making suggestions for conventions to be employed when subroutines appear in published programs.

Throughout the previous note it was implied that the parameters of subroutines were variables or the names of variables. A natural and useful extension is to allow parameters to be other names—a subroutine or place to jump to for example.

Consider a subroutine to calculate the two roots of a quadratic equation and having a special exit which is used when the roots turn out to be complex. Such a subroutine could be written as:

Routine: ROOT
parameters: (a, b, c, x, y, ALARM)
$D = b^2 - 4ac$
If $D < O$ GO TO ALARM
$x = (-b + \sqrt{D})/2a$
$y = (-b - \sqrt{D})/2a$
Exit.

It could be called by

DO ROOT ($a = 2$, $b = 3$, $c = 4$, $x \equiv X$, $y \equiv Y$, ALARM $\equiv$ STOP)

or using the positional notation

DO ROOT (2, 3, 4, X, Y, STOP)

A more important case arises when a routine uses another subroutine so that there is essentially a second entry which is the return from the subroutine. The standard example is that of a quadrature routine to compute $y = \int_a^b f(x)dx$.

This could be called in by

DO QUAD ($a = 0$, $b = 1$, $f(x) \equiv F(x)$, $y \equiv z$)

so that $z = \int_0^1 F(x)dx$.

In this example F is the name of a function and x is a dummy variable as in mathematics. Should a multi-variable function be used, the dummy variable will identify the selected variable. The dummy variable may have any name except those of the other variables.

In this manner, the quadrature routine is given enough data so that the auxiliary subroutine can be used correctly.

An intriguing example is that of a double integration. Let us define $F(x)$ which we used in the previous example as

Routine: $F(z)$
parameters: z, u, (implicit; name of result)
DO QUAD ($a = 0$, $b = 2$, $f(x) \equiv G(x, z)$, $y \equiv u$)
Exit.

Thus $$z = \int_0^1 \left(\int_0^2 G(x, v)dx\right)dv$$

For this result to be obtained correctly by a program, either two copies of the quadrature routine are needed or else two copies of the intermediate results have to be retained. In the previous note, it was implicitly assumed (in the SET statement, for example) that there was only a single copy of each routine available. This is the normal way in which compilers and programmers work for reasons of space economy (at least on relatively small computers!).

For this reason it is recommended that a single copy only of each subroutine is assumed in publications, and in the few cases where separate copies are needed, these are explicitly defined by the author, for example as QUAD 1 and QUAD 2. Thus a SET statement can and should define which copy is being set so no ambiguities arise.

Many similar problems arise when subroutines are used in "depth" and when the number of working space variables is minimised. Most of these are irrelevant in a publication language, where English explanations can be injected just as in ordinary mathematics.

COMMON BUSINESS LANGUAGE

The *BCS* committee on Auto-Coding for Business Problems has decided to change its original aims since the work on a common source language is now being done more or less full time by a committee of manufacturers in the *UK*, and the Department of Defence Committee on Data Systems Language in the *USA*. The *BCS* committee will now concern itself with studying and reviewing auto-code systems rather than trying to build a common source language for business.

The committee is hard at work studying various auto-code systems such as *IBM's* Commercial Translator, Remington Rand's Flowmatic, Honeywell's Business Compiler and COBOL. The committee will examine these systems to see if they can cope with the problems encountered in commercial processing, and it will issue reports from time to time explaining the systems to Society members, and perhaps comparing the scope of the various schemes.

BCS members can consider this committee as the focal point for information on commercial auto-coding, and it will do its best to answer any inquiries sent in to the Society's offices. A discussion of source language requirements will take place at the Harrogate conference in July.

The Department of Defence Committee on Data Systems Language has recommended the use of COBOL—Common Business Oriented Language—as the immediate source language for business problems.

COBOL has been produced by the Short Range Committee; and two other groups under the same sponsorship are working on the more long term solutions. It is likely that all *USA* manufacturers will write compilers for COBOL, though they will probably still keep their own auto-coding systems as well, so a common language can now be said to exist.

Manufacturers in the *UK* are considering whether to accept COBOL and prepare compilers (i.e. translators from COBOL language to their own machine language).

COBOL has already come under some criticism in America and Britain. Some people consider it was rushed and does not cover the ground adequately and the first report contains very few examples of how to use the commands and data descriptions. The creators of COBOL think that in the main anything that is said to be lacking is really part of the environmental description—i.e. will alter according to the type of computer used—and they feel that these points will be taken care of by the individual manufacturers concerned. This shows once again how difficult it is to produce a problem language which does not depend to some extent on the type of computer used.

It is hoped that *The Computer Bulletin* will be able to publish the framework of COBOL so as to allow it to be widely known in this country.

R. M. PAINE.

DISCUSSION GROUPS

As an indication to members the following brief summary shows the progress in two of the discussion groups during the winter session. It will be remembered that these groups are continuing unchanged next year excepting that new members may join if they wish to. It is again emphasised that the job of the discussion groups is to exchange views and those members who persistently do not attend may be dropped from the circulation list.

Operational Research in Business

The Chairman is Mr. E. W. Stevens-Wilson of *BISRA* and the Secretary, Mr. L. D. Read of *Kodak Ltd.* There are about twenty-five nominal members with about a dozen active participants.

The subject matter of the discussions has included linear programming, statistics and simulation studies and among the visiting lecturers, Mr. D. Smith a member of the Linear Programming sub-committee of the *Share Organisation* of America, Mr. Govier of *Esso Petroleum*, and Mr. Shenton of *Robson-Morrow*. The group also attended a lecture by Prof. A. G. Ivakanko of *Academy of Sciences* of Kiev on Production Control in Russia.

Advanced Programming

This extremely lively group is led by Mr. E. L. Willey of *Prudential Insurance Co.* The mailing list for the discussion group notes now numbers 40 and the active membership between 25 and 30. The subjects of discussion are ranging over all aspects of commercial auto-coding including, the accountants' requirements, the application to specific problems and the design of compilers. Visiting lecturers from *Ferranti*, *Elliots* and *IBM* have described auto-codes and an application experiment is being carried out using the Ferranti system. A sub-group is very busy just now working on COBOL.

P. V. ELLIS

ACCESSIONS TO LIBRARY, FEBRUARY–APRIL 1960

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REGIONAL BRANCH NEWS

BIRMINGHAM

The meeting on 13 January was concerned with the use of computers for the solution of logical problems. Miss C. Popplewell described the use of the Manchester University MERCURY for the scheduling of examination time-tables, mainly for the University of Birmingham. This is mainly a packing problem, with many restraints upon the solution. A typical job is the preparation of time-tables for two faculties, containing 1,800 students, taking 400 different papers, with any particular student taking one of 500 sets of papers. Accommodation is restricted to about 1,000 students for any session, with a maximum of 36 sessions. No student should take papers in both morning and evening sessions. It has been found that the computer can reduce the total number of sessions required compared with the previous trial and error methods. With the ever rising number of University students to be examined it is fairly certain that the use of a computer will be essential in the near future. The total time required for the solution is just over 30 minutes.

The remainder of the meeting was devoted to a description of the work that has been done by the British Railways (London Midland Region) in the production of railway time-tables on a DEUCE computer. The main feature of this problem is the very great amount of data to be stored before computation can begin. This includes the running times of all 20 or so classes of train between all signal boxes, their starting and stopping times, the times when the signal boxes are manned, the headway needed between trains, and the timing of all other trains travelling over the portion of track being dealt with. Of particular interest is the method of encoding the topological details of platforms, crossings and signals at each station, and which crossings are blocked by the various lines. The use of magnetic tape storage is essential for this problem; at the moment short sections of track involving between 40 and 60 signal boxes are tackled separately, and considerable use is made of the magnetic drum as an intermediate store. The program is now yielding useful results, and these will be compared with the existing methods of time tabling to decide whether further refinement of the programme is required. It is understood that similar work is being tackled by the Eastern Region using a Ferranti machine.

On 10 February, Mr. J. W. Harling gave a talk on Models of Stock Control and Production Scheduling. This was concerned with the problems of maintaining an adequate stock of some commodity when either the input or, more frequently, the output was random, and only statistical details of it were known. In this case no finite level of stock can give an absolute assurance of never running out, and the calculation must be based upon some prescribed minimum probability of running out. A more difficult case is that in which both input and output are subject to random fluctuations, and again the object is to produce a model which can be used to calculate for each scheme if re-ordering the chance of running out of stock. Mr. Harling pointed out that the calculations involved were simple, but that in a typical case concerned with stocks of many thousands of different items, it was profitable to use a computer on account of the large volume of data. This is particularly the case when the demand has seasonal fluctuations, so that the calculation of optimum stock level has to be made several times a year. The lecture concluded with a more complicated problem of manufacture, in which as well as stock-holding, the manufacturer was concerned with the order in which dies were put into a press to reduce the total cost of producing a number of different pressings. In this case the costs of changing from any one die set to any other die set were expressed in matrix form, and the computer was used to thread the matrix with minimum total cost. The problem is in fact insoluble but a near optimum solution can be obtained fairly quickly. In addition to this information the computer also examines the number of each item required, and from a knowledge of the cost of holding stocks, the frequency at which each item should be manufactured can be determined, and the level of stock to aim at.

BRISTOL

The Branch successfully concluded its first session of lectures on 22 March, when Dr. J. Corner of *AWRE* addressed a meeting on the subject "Digital Computers in Atomic Energy Research and Development." Dr. Corner gave a clear and illustrated account of the use made of the various computing facilities available, with particular reference to the powerful centre at Aldermaston. Lively questions showed the extent to which the audience had been stimulated by the lecture.

GLASGOW

On 22 February, some 30 members of the Glasgow Branch visited the *IBM* factory at Greenock, where they spent a most instructive and enjoyable evening. Although most interest was, naturally, shown in the 650 computer and RAMAC 305, members were also impressed with the well laid out factory and the production lines for the punched card accounting machines. *IBM* went to a great deal of trouble to make this evening an absorbing one and in this they certainly succeeded.

A talk on Operational Research was given on Monday, 7 March by Dr. K. D. Tocher of *United Steel* and was well attended, especially by members of the engineering and scientific group.

Dr. Tocher commenced by saying he would like to go rather outside the scope of his title, and talk about a number of other problems, not specifically concerned with operational research which had been solved on their PEGASUS computer. Most of these were concerned with the smelting and manufacture of pig iron and its subsequent treatment before its further manufacturing processes, so that he described the details of these processes first.

Some amount of scrap, whose carbon content is known, is put into the furnace to be smelted down. Subsequently the molten iron is poured into tubs, where it solidifies and further cools, and is then reheated for a period before further treatment in the form of rolling.

Among the problems of this process were the following:

(i) The cooling of the molten iron to the solid state and beyond, necessitating the solution of partial differential equations in three independent variables (time and two space variables).

(ii) The problem of arranging the mixes to be put into the pot, so that steels of different carbon contents can be made. Unfortunately, although the carbon contents of the scrap may be known exactly, the process is subject to some uncertainties so that the resulting melt may not come to have the contents expected. Thus, the preparation of steels according to a set of specifications is no easy task. An analysis was given enabling the solution to be found conveniently.

(iii) The problem of arranging the reheated ingots so that they were suitable for the subsequent rolling process. Here the factors on which successful rolling depends on are unknown, although obviously the times of rolling and reheating and the composition of the steel are all important. One is tempted to apply multivariate regression analysis—particularly because such a program is available—but we were warned against the indiscriminate use of the technique. However, a convenient method to apply was obtained by considering the probit response analysis for measuring the toxicity of poisons. In its original application, it is assumed that the fatal dose of poison varies for each animal and thus the observations (death or no death) can give some estimate of the mean fatal dose and hence the toxicity of the poison. An analogous situation exists in the reheating and cooling of ingots, the success or failure of the rolling process depends upon the length of time for which reheating carries out, but the time itself for each ingot depends upon the ingot. This form of analysis had been found to be successful.

Finally, Dr. Tocher described simulation techniques, and outlined some of his experiences in their use. All kinds of detail had been incorporated, an example being tea breaks, and the factors not deterministic had been included by various devices—a foreman who says either "yes" or "no" by a random binary digit. In order to facilitate writing such simulation programs, a translation program had been produced whereby statements in a convenient algebriac notation could be automatically converted to a machine program.

LEICESTER

On 11 February, Mr. J. L. Grover (*Courtaulds*) discussed "Initial Experiences with an ELLIOTT 405." Although some programs had been completed before the acceptance date, a detailed analysis for the first twenty weeks' working showed program developments to occupy most of the useful machine time. Mr. Grover spoke of the reassurance given by the availability of a compatible machine for urgent work.

Mr. J. E. Tinker (*Cheshire County Council*) spoke on 17 March on "Data Processing in Local Government." Three payroll programs were used for different groups of employees. One of these programs charged costs to appropriate accounts. A number of budgetary control statements were regularly prepared and comments were printed out for various kinds of exceptional expenditure.

MANCHESTER

On Tuesday, 9 February in the Manchester College of Science and Technology Mr. R. B. Baggett, a Director of *Messrs. Job White and Sons Ltd.*, spoke on "Production Planning by Computer."

The speaker began by describing to his audience of thirty-two members and visitors the types of knitwear produced by his firm and the various practical difficulties that were encountered. In their particular class of trade they offered a wide range of articles in a large number of colour combinations and because of the extensive range it was, generally speaking, only practical to manufacture articles for order and not for stock.

Mr. Baggett believed that anyone approaching a problem nad to have the right attitude of mind whether it was a production or a programming problem. Therefore, after much thought, they decided on an entirely new approach to the knitting problem and instead of dealing with weights of wool with hypothetical lengths which often varied by 5% or more, they dealt with actual lengths (using a safety margin of only 1%) and they issued the machine operator with the correct quantities of the correct colour and quality required to finish the job.

To do the necessary calculations time was hired on a 32-column card English Electric DEUCE, some 90 minutes being used each week; when later an 80-column machine was used they found that after improving the programme the whole job was reduced to 18 minutes. With the first system a card had to be punched for each fabric of each order and in addition some of the more standard items were dealt with manually; it was found, however, in practice that many errors occurred in the manual work and when the larger card which could hold a complete order was taken into use, the opportunity was taken to place all planning under the control of the computer programme.

This first project produced each week the detailed production and materials plan for the business for the following week. To this has been added a Stock Valuation program (the computed stocks being compared with physical stocks every three months and amended where necessary) and a Sales Forecast program which is primarily being used to estimate orders in the coming season so that useful productions can continue during a slack period.

A Cost Control program is being tested now and it is hoped that it will be used soon. A wages program is not yet in hand, although some basic thinking about the problems has occupied some of Mr. Baggett's time.

The work achieved so far has been done as a series of separate problems. The lecturer said that his thoughts had for some while been turning to a second stage where the output of one week was used as the input of the following week and where the output of one program was used as the input of another program that same week. The eventual aim was that the whole process would be triggered off by the preparation of a confirmation of a purchaser's order; all the following phases would use their own master or balance information as required. The speaker said that as a result of his four years' experience in programming and using a computer he realised that it would be some years yet before his target would be reached.

On 3 March nearly fifty members and their guests gathered in the Manchester College of Science and Technology to hear Lt.-Col. L. D. Slater, M.B.E., R.A.P.C., speak on "The Royal Army Pay Corps Computer Application." Lt.-Col. Slater spoke for over an hour on the work already achieved in preparing to maintain soldiers' accounts with an *IBM* 705 and of the planning for the future.

NEWCASTLE

On Tuesday, 2 February, Mr. W. S. Ryan of the *General Post Office* addressed the Branch on "Data Transmission in Relation to Computers and Data Processing Systems." An excellent film on Telex was shown illustrating the preparation of punched paper tape, the transmission of data by this means and its subsequent conversion to punched cards.

Mr. Ryan then proceeded to discuss various media for data transmission, including:

1. *Mail.* The point was made that this means was adequate for most systems to make the data available at the computer centre in time for the system to work with the required efficiency.
2. *Telegraphy* (Line Transmission). This has a fundamental attraction since it is almost universally two state. Costs and accuracy requirements were discussed. Checking on data preparation and transmission was essential; on the latter various techniques were mentioned, including check digits, double transmission in one direction, simultaneous transmission in both directions, etc.
3. *Punched Cards.* A brief mention was made of systems giving four to five cards a minute on telegraph circuits.
4. *Transmission at Time of Transaction.* Treatment of airline reservations was used as example where data is regarded as perishable, has to be processed immediately, and the results transmitted back.

On Tuesday, 8 March, Mr. M. I. Musk, of *Courtaulds Ltd.*, spoke on "The Computer and Monte Carlo Methods." Mr. Musk began with an explanation of simulation, which involved a study of machines, decisions, and events stemming from the decision. An essential element was the time scale which was of necessity collapsed.

Two types of simulation were discussed:

(*a*) Deterministic. Here an example of paper and pencil simulation for stock control was given.

(*b*) Stochastic. Here sampling was required from the appropriate distributions using random number generation.

Mr. Musk pointed out that it was desirable to have simulation of the general industrial situation where particular sub-routines could be used often, and this necessitated the writing of a general simulation program.

DEUCE USERS' COLLOQUIUM ON LINEAR ALGEBRA

The fifth DEUCE Users' Colloquium, on topics in linear algebra, was held on 4 March, 1960, at the Russell Hotel. The chair was taken by J. M. Hahn of *Bristol Aircraft Company*.

The colloquium was the largest so far, with about 140 people attending, and in some ways the liveliest. The major contribution to the early part of the colloquium, and in fact to the rest of it as well, came from J. H. Wilkinson of the *National Physical Laboratory*. The colloquium finished in slight disorder with a graphic demonstration of Kron's method of tearing.

Session 1. Accuracy of Results

In the first session, Mr. Wilkinson discussed error analysis and G. Z. Harris (*RAE*) described a method of inverting nearly singular matrices by using latent vectors. In the time available Mr. Wilkinson could give only a sketch of his recent theories and methods; he showed that for several common algebraic processes, the (inaccurate) results produced by calculation to a given precision may be regarded as the completely accurate results for a problem with perturbed coefficients. These perturbations were often surprisingly slight; for example, if the determinant of an $n \times n$ matrix is calculated by triangular decomposition with interchanges and double-length accumulation of scaler products, the result will be the exact determinant of a matrix differing from that given by less than $\frac{1}{2}$ in the last place of any coefficient; in practical problems, this will usually be within the accuracy to which the coefficients are known. Other processes discussed were solution of linear equations, eigenvalues of symmetric triple-diagonal forms and zeros of polynomials. In discussion, the author was unable to forecast the publication date of his eagerly awaited book on "Error Analysis in Algebraic Processes" but mentioned that he would be contributing a chapter on the subject to the second edition of "Modern Computing Methods", now being printed by *HMSO*.

Mr. Harris described a method of inverting a symmetric matrix by finding its latent vectors, compounding these into a matrix Q, calculating $Q'AQ$, which is a diagonal matrix, and then forming

$$Q(Q'AQ)^{-1}Q' = A^{-1}$$

Comparing this method with the library program using Gaussian elimination, for nearly singular matrices, this method sometimes produced results for matrices which the other refused, and generally gave lower residuals.

In discussion, Mr. Wilkinson suggested that the comparative success of the method was associated with the very great care with which the latent root routines had been programmed. Direct solution by triangular decomposition would probably produce equally good results; alternatively, direct solution by elimination using double-length arithmetic would take no longer than the latent vector method.

Session 2. Calculation of Latent Roots

The second session consisted of a review by Mr. Wilkinson of existing methods of calculating latent roots. The review was confined to methods for which DEUCE programs had been distributed and which had not, in the authors' opinion, been superseded. Methods referred to included those of Givens, basic iteration, Lanczos, Wilkinson-Lanczos and inverse

iteration; a program was also mentioned which found the zeros of a polynomial whose coefficients were matrices with complex coefficients. The methods were compared for accuracy, speed, storage requirements, operating convenience, etc.

In discussion, the author referred to some of his published work, and references are given below; he pointed out, however, that several of the methods in the earlier papers had now been superseded.

Session 3. *Applications of Linear Algebra*

Most linear algebra on DEUCE is done by means of Scheme B, an interpretive system developed initially by M. Woodger and B. W. Munday of *NPL* at the behest of Mr. Hahn, and subsequently augmented profusely by DEUCE programmers everywhere. The scheme comprises a General Interpretive Program and a large number of Bricks; for a particular job, the bricks specifying the individual operations required are packed together with *GIP* and a program of codewords by which *GIP* controls the sequence of bricks obeyed (Robinson, 1959).

Scheme B is not confined to linear algebra, and is useful in any job in which the data is conveniently handled in the form of arrays. Session 3 of the colloquium covered various application outside the strictly linear algebra field. A. Gilmour (*English Electric, Central Computing Service*) described Design Office Calculations in which Scheme B is used to handle and interpolate multi-argument empirical design curves stored in the form of tables. M. Kingsbury (*English Electric, Central Computing Service*) described Pumped Storage Calculations in which Scheme B was used to handle vectors representing demand load curves, costs per unit and efficiencies of different generating stations, and so forth. Mr. A. D. N. Smith (*RAE*) described the use of Linear Algebra Programs in the field of Aircraft Flutter; the various matrices involved in calculating flutter were assembled by using standard scheme B bricks; Mr. Smith also referred briefly to the use of such bricks in other fields, taking as an example the calculation of a complicated integral over ranges of parameters for which recurrence relationships could be found.

Session 4. *Handling Large Matrices*

The fourth session started with two papers by G. Pitt, J. Halliday and P. H. Roberts ((*English Electric Aviation, Warton*) on the Application of Partitioned Matrix Methods to Structural Problems and on the Inversion of Large Band Partitioned Matrices. The techniques described had arisen from the need to manipulate large matrices associated with aircraft structural problems. The matrices were handled in partitioned form, the form of partitioning being related to the structure being studied. The papers described the analysis of structures in terms of force and displacement and outlined the course of the computations. Two major programs were described; one was for inverting a band partitioned matrix, that is, a matrix in which all partitions are zero except those on a central band of three or five partitions. The other program was for multiplying partitioned matrices; in this program, all partitions are numbered, and the computer indicates to the operator which partitions from each operand matrix will next be required; searching among the card-stored partitions is done by the operator concurrently with computation by the computer. There would thus be only limited gain in speed from using magnetic tape storage, though there would presumably be some improvement in operating complexity. The programs described form part of a comprehensive scheme for dealing with card-stored partitioned matrices and incorporate a number of features for controlling and simplifying handling and for economising time and storage.

The last paper was by K. L. Stewart and G. J. Tee (*English Electric, Mechanical Engineering Laboratories*) on Piece-Wise Inversion by Diakoptics. It described, with examples, Kron's method of tearing. In this method, a complicated structure to be analysed is divided into a number of pieces; the pieces are analysed separately and the results combined by analysing a linking system. The advantages are the reduction in size of the system to be studied at any one moment (e.g. size of matrix to be inverted), and the fact that minor modifications to the system can be studied by recalculating only the part affected.

In the discussion, there was some criticism of the clarity of the presentation, it being suggested that the method was very valuable and powerful and was not difficult to use, but that obscurities tended to be introduced by people describing it. One difficulty seems to be that the division of the original structure has to be guided by a physical appreciation of the structure being studied; furthermore, rigorous proof of the procedure depends on results in algebraic topology. As a result, it is difficult to find an account of the computational procedure which is not confounded with a particular application in electric networks or elastic structures, with algebraic topology and with many other topics as well. This has led to both the method and the expositors being considered obscure and difficult.

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BOOK REVIEWS

Management Technology, Monograph No. 1

Edited by Roger C. Crane and C. West Churchman, January 1960; 92 pages. (New York: *Institute of Management Science*, $2.00)

Readers of *Management Science*, which continues to be the principal journal of TIMS, are accustomed to deal in probabilities, when confronted with anything new. That journal will continue to be research-oriented, highly technical, and will often require a knowledge of advanced mathematics.

The new *Monograph* may be the first of a series, and it aims at presenting case histories, papers on business applications of statistical methods and management discussions. This objective has led, in the first issue, to what another member of the Editorial Board found to be too embarrassing a variety of subject, for a concise review. The variety, however is mainly in the areas of application, which include a textile mill, a jam factory, a precision-engineering works, and a missile-system.

Behind this variety, the fundamental techniques used are based on those which were established by (now) classical statistical methods twenty-five years ago, and which have more recently been developed and extended by operational researchers, linear programmers and others. Some of these workers have tended, in their published work, to write freely about the new mathematical techniques, which are beyond the understanding of the mere businessman, at the expense of overlooking the fundamental preliminaries of any statistical method.

It is thus reassuring to the pedestrian, in this age of space-travel, to find a monograph which emphasises that the sensitivity of any control system, based on calculations, will depend on the inherent sensitivity of the collected data. This simple fact is sometimes stated by phrases such as "modelling input variables" (p. 33), or "data augmentation" (p. 87) and there is one paper which is devoted entirely to aspects of measurement (p. 36 *et seq.*). In the textile mill we meet a situation where we are told bluntly that the search for the new data had established for the first time reliable quantitative measures of the operations performed (p. 53).

We realise the heavy load on honorary editors to attain a good standard and how difficult it is to persuade authors to give proper attention to their tables and diagrams. If the objectives of this monograph series are to be attained, then authors must give more attention to the headings and ordinate labels of graphs and the titles of tables, and to the explanation of processes in simple English, with all the mathematics in a footnote or an appendix. If this is not done, then your reviewer fears that managers who are not already buyers of these techniques, in their old or new guises, will remain untouched by these communications; the *Monograph* will then tend to be regarded merely as an overflow from the principal journal of the Institute.

We applaud the objectives of the TIMS Editorial Board and hope that these mav ultimately be attained, because the need is great.

H. W. GEARING

Clerical Job Grading and Merit Rating

1960; 91 pages. (London: *Office Mangement Association Ltd.*, 35s. 0d.)

This information in the previous edition has been brought up to date and a number of new specifications have been added. Amongst these additions is a very commendable effort to grade programmers, operators, data preparers and maintenance engineers working on electronic data processing systems.

This book presents a practical method of clerical job grading and merit rating suitable for both small and large organisations. The analysis of jobs into various tasks has been done on a simple broad basis. This avoids the problems arising from more detailed sub-divisions and provides a system of grading which can be handled by experienced supervisory office staff.

Part 1 is explanatory. It shows clearly how a job grading scheme, together with a merit rating scheme can be prepared and installed. Particular care has been taken in studying the best method of obtaining the acceptance of such a scheme by office personnel.

Part 2 provides details of grading specifications. A very comprehensive range of clerical procedures is given. Each procedure is sub-divided into its component tasks. A general description of each task is shown together with its assessed grades. Some specifications are more detailed than others. These are marked "Provisional" and readers are invited to send criticisms and suggestions to the secretary of the Association.

The specifications dealing with commercial and accounting work are more detailed than those associated with clerical work in the factory. This applies particularly to "Production Control" (Provisional). No mention is made of the need, in some industries, of some technical knowledge of the product manufactured as a background for some factory clerical tasks.

This is a very practical book and is the result of organised research. It provides valuable background information for any organisation planning to operate a clerical grading scheme. It is very good value for its modest price of 35s.

L. R. CRAWLEY

A Primer of Programming for Digital Computers

By Marshall H. Wrubel, 1959; 230 pages. (London: *McGraw-Hill*, 58s. 0d.)

This book is addressed to scientists and engineers who are interested in the computer as a research tool, and who wish to find out enough about programming to be able to formulate their problems in computer terms, without having to go too deeply into either the logical structure of the computer, or the niceties of programming.

Professor Wrubel has chosen to illustrate the various concepts by reference to a single computer, the *IBM* type 650. This, of course, restricts the appeal of the book, but the alternative of using the made-up code for a non-existent machine, is very unsatisfactory; programming of non-existent computers soon becomes a tiresome occupation, and anyhow, programming can only be learned by contact (frequently humiliating) with real computers.

The book is divided into two parts. In Part One, which covers elementary programming, the basic 650 code is not introduced, but instead, all the ideas are illustrated in terms of the Bell Laboratories interpretative code, which causes the 650 to function as a sequential 3-address fixed-point machine, This part contains a lucid and unhurried development of the

basic ideas, such as fixed—and floating-point working, the various types of jump instructions, loops and branches, flow diagrams and program "debugging". Input and output by means of punched cards are clearly explained, with the help of several full-scale reproductions of appropriate punched *IBM* cards. Part One ends with a chapter on automatic programming, which gives a useful summary of the leading concepts of FORTRANSIT.

In Part Two, which covers advanced programming, the reader is introduced to the 650 order code, and the logical structure of the machine. The explanation of drum-storage leads to the concept of program optimisation, which, in turn leads to SOAP (Symbolic Optional Assembly Program), which was invented to use the machine to optimise its own program. The last part of the book is devoted to a discussion and comparison of SOAP and machine language.

The book concludes with a glossary of the main terms used.

While the book is chiefly directed at those who are learning to program the *IBM* type 650, nevertheless Part One should prove useful to anyone engaged in the training of programmers, and the sections on FORTRANSIT and SOAP should prove interesting to advanced programmers of other machines.

The printing and production of the book are excellent.

D. J. McCONALOGUE

Electronic Computers

By E. H. W. Hersee, 1959; 104 pages. (London: *Blackie and Son Ltd.*, 12s. 6d.)

The author presents the basic working principles of both digital and analogue machines. He expresses a hope that the book may prove a useful introduction of the subject to future mathematicians and engineers. This is a reasonable claim for scientific and technical readers at the National Certificate or GCE Advanced level. The book serves a useful educational purpose and can be recommended for the appropriate University and Technical College students.

M. B.

The ABC of Electronic Brains

By Leon Bagrit, 1960; 46 pages. (London: *B.B.C.*, 1s. 6d.)

This is the series of six talks broadcast in the External Service of the *BBC*. Its prose is fluent and the reader will find it hard to put down the booklet once he has begun. There is a generous sprinkling of pictures and diagrams. Members going to the Harrogate Conference by train will do well to choose this as a travelling companion.

M. B.

Electronic Computers and Their Business Applications

By A. J. Burton and R. G. Mills, 1960; 330 pages. (London: *Ernest Benn Ltd.*, 45s. 0d.)

The preface to this book stated that "This book aims to help businessmen to understand what is involved in the use of large-scale electronic digital computers and to be a survey of business applications for the computer specialist." Unfortunately these aims are so dissimilar as to make them difficult to deal with in one book. The sections describing computers and how they work in simple terms does not interest the computer specialist and the survey of business applications is too general to interest the business man, who is faced with the difficulties of a particular application.

All this is not, however, to condemn the book, for to try to include too much is less of a fault in an introductory work, than to cover too little ground.

The book uses a novel teaching technique, in that it postulates a mythical computer, "Casseac", which the authors have designed as a typical business computer, in order to describe how computers function, are programmed and applied in practice. The authors are well known for their lectures at the Sir John Cass College, and their experience there has clearly shown them the ideal way to introduce businessmen to computers almost painlessly.

Probably the most useful function of the book is that it very clearly sets out the size of the programming task involved, in converting the clerical work of an office to electronic data processing, which is all too often underrated.

The book suffers from one defect common to many on this subject, in that when a controversial issue is faced, one side of the argument is adopted, without clear reason for the choice. A particular example is the division of programmers into programmers and coders. The authors observe that there are two viewpoints, but give little reason for the split, which they favour, except for that woolly cliché, "division of labour," and opponents of the split could well refer the authors to Parkinson's Law on staff accumulation.

There are few inaccuracies in the book but two must be mentioned. First, to say that the City Treasurer of Norwich in installing the forerunner of English business computers led the way in this country in 1956, is to do a great injustice to J. Lyons & Co. Ltd. In one of the chapters on programming (Chap. 10 p. 126) the authors speak of the love programmers have of making their work unnecessarily involved, yet a little later (chap. 11 p. 143) the following phrase occurs . . . "the need for attractive instruction codes, *mainly for sales purposes* . . ." This suggestion is incorrect and hard to reconcile with the previous statement, for the more powerful the order code available to the programmer the easier it is for him to keep his program simple.

The book would, I feel, have been greatly improved in the description of typical application, had the authors been able to obtain the services of actual users to write them. The local government application is excellently described and this part was contributed by a user. The payroll description is also very thorough and it seemed that the authors were on more familiar ground here than with some other applications; e.g. banking and insurance which are dealt with in very general terms.

The book, is however, well worth 45s. First, to the businessman, who has to face computer installation, for the clear introduction to computers and the problems involved in installing them. (That is provided he skips lightly over the very detailed description of coding and reads other books also, to avoid only seeing one side of controversial issues). Secondly, to the computer specialist, not for the survey of business applications as intended, but as a model of how to introduce the businessman to computers without terrifying him.

D. BISSETT

Cutting the Cost of Your EDP Installation

Canning, Sisson and Associates, 1959; 173 pages. (Los Angeles; $20)

That this book concerns itself solely with one aspect of Cutting the Cost of your EDP Installation must not be considered to inhibit its value. It is pointed out that the cost

of planning and preparing your computer site can amount to nearly a quarter of the total installation cost. This proportion can be expected to rise as the cost of programming decreases.

Whilst not recommending this as a bedside book, it should definitely be on the reference bookshelves of those who have just ordered or are about to take delivery of one of the "monsters."

It is apparent from an interesting record of typical running times that over a third is normally unproductive. There is no doubt that unproductive time accrues in an inverse ratio to the care taken over the original installation. It is presumably this important point which has prompted the writing of the report.

However, some of the standards may be a trifle hard to attain, even in this country where experienced computer men abound! The authors require that an installation manager should be:

> "acquainted with EDP equipment and programming and he should have as much experience as possible with data processing operations, through tab (punched card) or previous EDP work . . . a good knowledge of company's personnel and organisation . . . with your firm for at least two years . . . appreciation for construction and space utilisation . . . appropriate managerial talents."

The most valuable parts of the book are undoubtedly the charts and numerous check lists, the latter being reproduced in a tear-out form at the end of the book. These lists cover such factors as "Tone," Floor Area, Power and Storage and include specimen figures based on the reports, which latter take up a quarter of the book.

These reports are both useful and clear, covering the UNIVAC, 702, tape 650 and the 205. Information given includes cost, space, air conditioning and power supply. In a summary of statistics it is interesting to see the figures involved for certain installations, e.g. 12,900 square feet for the 702 and associated equipment, storage and viewing space. One Company decided it was worthwhile erecting a new two storey building for its 709 resulting in total installation costs of $575,000!

With the advent of transistors there is no doubt that less stringent conditions are imposed on the user of a computer. However, the increasing use of magnetic tape brings with it its own problems of dust and damp protection. The problems of finding space, floors that will carry the weight and a site that will suit everyone, will always be with us and, therefore, this book is particularly welcome.

G. S. MORFEY

Economic Control of Interconnected Systems

By L. K. Kirchmayer, 1959; 207 pages. (New York: *John Wiley & Sons, Inc.;* London: *Chapman & Hall Ltd.*, 100s. 0d.)

This is a companion volume to Dr. Kirchmayer's previous book "Economic Operation of Power Systems" and extends the scope of that book to deal with interconnected power systems (power pools) and mixed steam/hydro generation systems. Its interest is slanted toward American engineers responsible for the parallelled operation of self accounting companies forming a power pool, but even so, the techniques described may well have applications in other countries in view of the very large and complex networks which now have to be controlled.

The text covers much of the American work on economic operation and control of interconnected power systems not already dealt with in the previous book, a knowledge of the contents of which is desirable for understanding the present volume. In particular, methods of calculating transmission losses on interconnected systems are derived, and coordination equations obtained for the most economic operation of generation in parallelled systems. Multi-area dispatching computers based on this theory are described. The book also contains chapters on the dynamic performance of interconnected systems, on dispatching computers which will maintain frequency and economic allocation of generation within an area and provide a given interchange with adjacent areas, and on the short term economic co-ordination of steam and hydro plant. Optimum reservoir drawdown is only mentioned very briefly.

Matrix algebra and Lagrangian multipliers are used in the derivation of the transmission loss and co-ordination equations. The numerous illustrations defining the various power flows, and physical explanation of terms in the co-ordination equations aid considerably in understanding the results of the reference frame changes and algebraic manipulations described. Numerous references for further study are included and also a number of problems for solution, based mainly on networks used in the text.

The book is intended for advanced students, but it will be equally valuable to engineers working in this field.

U. G. KNIGHT

Reciprocals of the Integers from 1000–9999

By T. H. Redding, 1960; 42 pages. (London: *Taylor and Francis Ltd.*, 18s. 6d.)

This six-figure table lists $10^6 n^{-1}$ for the integers 1,000 to 9,999 displayed as a thousand entries on each of nine double-page spreads. The reviewer has checked every tenth value without detecting any errors. The table is intended for use with desk calculators but will not readily replace the cheaper Barlow's Tables which give reciprocals of every integer from 1 to 10,000 to seven significant figures with first differences.

The book contains an appendix on mechanical barrel-setting calculators intended to provide instruction on how to perform simple calculations. In an effort to give general instruction, the author loses the reader in a profusion of detail—over 450 words being used to describe how to calculate *pq*. The reader's attention, moreover, is distracted by missing articles, some spelling mistakes, a profusion of commas, braces and semicolons, and split infinitives. Fowler would not have found "to, effectively, transfer", which appears on page 34, an acceptable grammatical form!

The author fails to deal adequately with round-off. As a result he gives as worked examples

$$856{\cdot}7 \times 1{\cdot}23 \times 531{\cdot}246 \times 7{\cdot}2 = 4{,}030{,}528{\cdot}97664$$

$$748{\cdot}6428 \div 1{\cdot}63 = 459{\cdot}2$$

$$7{,}2501 \div 47{,}869 = 1{\cdot}514$$

and $$748{\cdot}6428 \div 1{\cdot}63 \div 2{\cdot}43 = 196{\cdot}2$$

all of which are wrong.

The book is printed on good quality paper, but seems to be rather expensive.

A. YOUNG

Logical Design of Digital Computers

By Montgomery Phister, 1958; pp. xvi + 408. (New York: *John Wiley and Sons Inc.*, London: *Chapman and Hall Ltd.*, 84s. 0d.)

This is a very useful book which attempts to provide the tools and methods for the complete logical design of general or special-purpose computers. A number of limitations in the logic and simplified forms are made which restrict the usefulness of the book, e.g. there is no reference to "threshold" or "ballot-box" logic. At first sight it appears that logical design will be reduced to an almost mechanical process but the author admits that "the most efficient and interesting computer systems are the result of flashes of inventive genius."

After two introductory chapters on computer design and the binary system comes a chapter on Boolean Algebra. This is of a pure mathematical form and in view of the almost complete use of visual aids—i.e. truth maps—later it seems out of place to reproduce such formal proofs of a few simple theorems of Boolean Algebra. However by chapter 4 the book is well into its stride and here we have a clear and valuable exposition of three methods of simplifying Boolean expressions, viz. the Quine prime implicant, the Harvard table, and the Veitch diagram. It is most useful to have these methods so clearly explained and readily available in one book. The Veitch method is finally adopted in the book and its advantages when redundancies occur or can be introduced are made evident. Another valuable chapter is that dealing with the design and simplification of sequential switching systems in which the Huffman–Mealy technique is described and applied.

Further chapters then use these processes to design the main sections of a digital computer, i.e. Store, Input-output, Arithmetic and Control. Finally a scaled down general purpose computer and a special purpose computer are designed in fair detail.

The book is restricted to the logic of synchronous circuits and most examples illustrate serial binary computers although there are a few on decimal and on parallel machines. There are good exercises and a bibliography at the end of each chapter. The exercises develop alternative solutions to some of the examples and should be useful in improving the non-expert's skill. The references end with May 1957 and so one finds nothing on such logical matters as parallel programming and interrupt. In fact the chapter on Input-Output is somewhat scanty.

The book is of excellent appearance and a pleasure to handle and the methods described should furnish one with the means to reduce the "purely material operations, so sparing intellectual labour, which may be more profitably employed" (Babbage). Unfortunately a number of errors, mostly misprints, occur which may impede the progress of the learner. The following corrections have been found:

Page 36, last line, for **1** read $\mathbf{1}_1$

Table 5–2 headings, interchange g_1 and g_2

Page 124, first equation, for a_0 read $\bar{a}_0$

Table 6–21 will not reduce

Page 254, equations (9–13) and paragraph, for 2^{n+1} and 2^{n2} read 2^n and 2^{n-1}

Page 335 (10–5), omit $(T_0 + T_1 + T_2)$

Page 365, Flip-flop C_4, for (read in) put (read in), jump.

P. Taylor

THE PSEUDOMATIC COMPUTER

(*A ten-minute address delivered on Friday*, 1 *April* 1960, *to mark the anniversary of the founding of an Organisation and Methods Department.*)

This morning I would like to tell you something about the PSEUDOMATIC Computer.

This is a high-speed, solid-state machine, with a working store consisting of a matrix of COROTITE nodules,* making use of the Hubbard–Eschelbacher effect.

This computer has a number of unique features, one of which is its use of Peripheral Programming. Now, it is a truism that the one thing which stops a computer computing is having to wait for its peripheral equipment. As computers become faster, and thus more costly, this waste of computing time becomes more and more serious.

In the last few years many attempts have been made to reduce this wastefulness by the introduction of various schemes of time-sharing and parallel programming. Parallel programming, in one form at least, involves the simultaneous running of two or more programs which are entirely unrelated to one another. When one program calls for access to or from a peripheral unit, the computer switches to another program, and later, when the unit has been duly attended to, promptly switches back again. But the various parallel programs, like the lines after which they are called, never meet, and thus must be unrelated to each other.

In the PSEUDOMATIC, our philosophy is to allow the peripheral units the greatest degree of autonomy, and it is in order to make this possible that we have developed the idea of peripheral programming. Most computers have only one order register. However, there has been at least one previous breakaway from this limiting circuitry. The Bull GAMMA 60 already uses a number of order registers, one associated with each peripheral unit, in order to make the best use of its parallel programming facilities. In the PSEUDOMATIC, this has been taken a stage further. Our peripheral units are controlled by a system of interrelated and mutually-controlling order registers, designed to take care of the housekeeping of all the peripheral units, be they card readers, card punches, printers, magnetic tape decks, or what have you.

A unique feature of the PSEUDOMATIC Computer, from which indeed it takes its name, is its ability to work with pseudo-numbers. In case some of you are not familiar with this term, I will digress for a moment to explain. No one here, I am sure, will fall into the trap of confusing pseudo-numbers with pseudo-random numbers, much less with imaginary

* See illustration, p. 74, *The Computer Bulletin*, December 1959.

numbers. The latter, I need hardly remind you, are square roots of negative numbers, and although termed "imaginary" they are of very real use in many fields of mathematics, and have strictly practical applications, notably in alternating current theory.

Pseudo-random numbers, on the other hand, are used as substitutes for truly random numbers. When solving problems involving queueing theory, or other stochastic processes susceptible of solution by Monte Carlo methods, there is a real need for random numbers. Unfortunately, there are difficulties in making a computer generate numbers which are truly random. However, it is possible to devise methods of producing series of numbers which are sufficiently random, and it is these which are called pseudo-random numbers. You will observe that it is only the randomness which is pseudo: the numbers themselves are perfectly real, ordinary numbers.

The pseudo-number is different in a much more fundamental way, and it is a very powerful addition to the computing art, filling as it does an aesthetically unsatisfactory, as well as inconvenient, gap in the normal working of digital machines. Now although the *Concise Oxford Dictionary* defines them less concisely, numbers may be defined as a system of notation designed for the description of discrete quantities. Generally speaking, in business, we deal to a large extent with discrete amounts, expressible precisely by a few integers, and we get on with them well enough. But we do not need to go very far into mathematical problems before we run into trouble. Let me explain what I mean.

Cast your minds back for a moment to your nursery days, and you will doubtless recall the difficulty that arose in dividing two buns between three people. The ancients solved the problem of representing this mathematically by introducing the notion of fractions. But vulgar fractions are remarkably intractible to manipulate in anything but the simplest of arithmetic. Much later, decimal fractions were introduced. These are, indeed, a great improvement, but frequently involve some degree of approximation, which is not only untidy, but can lead to cumulative error, particularly in automatic computing. When using the common radix of 10, division by any number which is not a power of the factors of 10 (i.e. 2 or 5), or a combination of them, results in a recurring decimal. The same is true, of course, of any other radix, and in binary working, since the radix 2 has no factors but 2 and 1, division by anything but a power of 2 results in a recurring figure.

But the approximation enforced by the use of ordinary numbers goes deeper than this. The two greatest constants in mathematics, π and θ, cannot be expressed precisely by any system of decimals or fractions, and the same is true, except for a few special cases, of all trigonometrical functions, and of logarithms.

Here, then, is the need for pseudo-numbers—a way of representing precisely what cannot be so represented by real numbers.

And how does the PSEUDOMATIC Computer realise this concept of pseudo-numbers? The answer is rather neat—by a combination of floating point digital and analogue working. Exact and integral amounts are held and manipulated digitally, while quantities inexpressible exactly are held in analogue form.

By this time it may not surprise you to learn that, in addition to performing normal arithmetic with pseudo-numbers, the PSEUDOMATIC can carry out pseudo-arithmetic with normal numbers. To those who are unfamiliar with this concept of pseudo-arithmetic, I should perhaps explain that it is somewhat akin to Boolean algebra. Pseudo-arithmetic can perhaps be most simply described as the digital manipulation of multiple operators.

Finally, a word about programming. It might be thought that a machine with so many unusual features would be rather difficult to program. Many systems of automatic coding have been devised during the last few years, varying from the simple PEGASUS Autocode, in which orders are written in a pseudo-algebraical form, to the UNIVAC "Flo-matic" code, developed by Dr. Grace Hopper and her team, in which orders are written in plain English. In the PSEUDOMATIC we have followed a rather different line. The programmer writes in the form of machine-type orders, but internal subroutines transform these as required for dealing with pseudo-numbers, and with overall control of the multiple order registers.

* * *

Note: Readers are invited to suggest possible fields of application for this novel machine.—Editor.

Solartron Activities

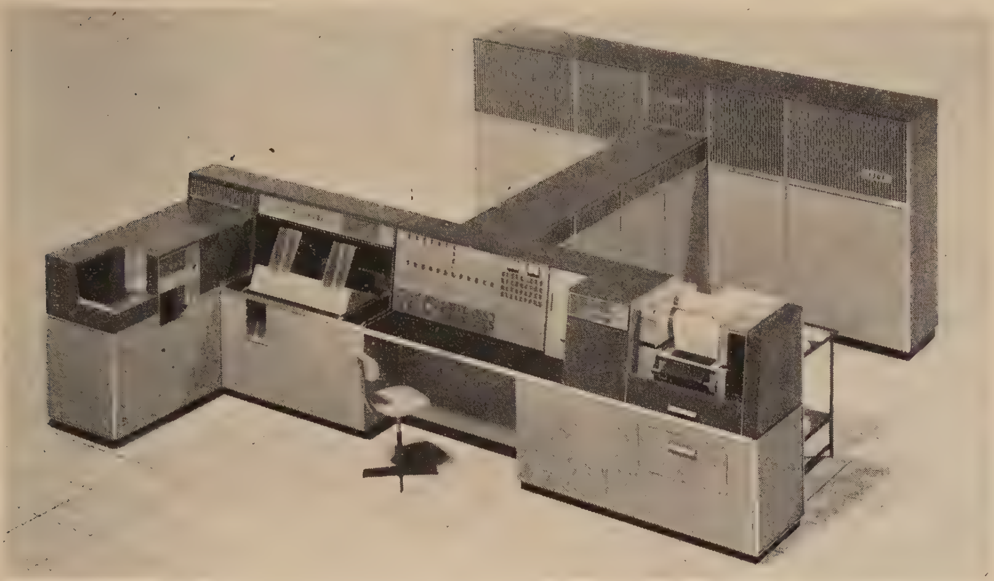
An agreement has been signed for *Firth Cleveland Ltd.*, to acquire a 53% interest in the *Solartron Electronic Group Ltd.* This will provide £900,000 to ensure the adequate financing of Solartron's next five-year period of development and expansion.

The *Solartron Electronic Group* and *John Brown & Co. Ltd.*, have formed a new company *Solartron–John Brown Automation Ltd.* This new company are manufacturing and marketing in the UK and Europe an automatic warehouse system which was invented in the USA by Mr. Donald Gumpartz, who has had an installation working for two years in America. The automatic warehouse system calls for a combination of electronic and mechanical engineering skills which is provided by the two parent companies.

The main interest in the computer field of this new venture is not only the spread of control engineering to new applications, but also the possibility of an automatic accounting function as a by-product of the system of selecting and packing warehouse orders. The makers say it can fit in with any office system—hand, punched card or computer—but there is a great opportunity here to carry the mechanisation a stage further to the accounting for orders. For instance, the media—possibly a punched card—that is used to operate the conveyors or chutes containing the merchandise, obviously could contain the necessary information to invoice customers and control stock without the need for additional punching or writing.

THE ICT 1301 DATA PROCESSING SYSTEM

by L. W. Robinson



Basic model including card reader, card punch, line printer, one drum and four hundred words of core store.

Concept and General Description

The ICT 1301 Data Processing System was designed with the following objects in view:

1. To cater for a wide range of organisations, from those requiring a simple punched card data processing system with high processing speeds, to those requiring a fully integrated, very fast magnetic tape system.
2. To be able to increase the size or the speed of the machine originally installed to meet the requirements of a growing organisation.
3. To provide a machine that is simple to operate and simple to program.

The basic 1301 is an 80 column punched card machine consisting of card reader, line printer, card punch, 400 words of core store and a 12,000 word drum. The core store may be increased to 2,000 words in steps of 400 and the drum storage may be increased to 96,000 words by the addition of 7 drums. Up to 8 magnetic tape transports may be added to the machine and two systems of magnetic tape are available:

(*a*) High performance, with a rate of 90,000 decimal digits per second.

(*b*) Standard, with a rate of 22,500 decimal digits per second.

A single address system of programming is used and a comprehensive auto-code is available. Time sharing is used extensively especially during input and output.

The machine operates at a pulse rate of 1 megacycle, is fully transistorised and the wrapped connection technique of joining wires is used throughout. All peripheral equipment is entirely under control of the program and no plug boards are required for the routeing of information, nor are there any large, costly buffers.

A basic machine can be installed in a room of 500 square feet; requires a maximum floor loading of 100 lb. per square foot; needs a three-phase mains supply within the range 346 to 440 volts; operates in a temperature up to 40° C and a humidity of 50 to 85% and dissipates only about 6 kW in heat.

Storage

The word length of the machine is 12 decimal digits, and alphabetic characters are represented by two digits.

A minimum magnetic core store of 400 words is provided, and this core store may be increased to 2,000 words in units of 400.

One drum is provided with the basic machine and a further seven may be added. Each drum holds 12,000 words divided into 60 channels of 200 words. Each channel is further divided into 20 decades of 10 words. Transfers to or from the drum may be in either decades or channels. Any number of decades up to 20 may be transferred in one instruction. The drum speed is 5,240 r.p.m. and the fast average access time for a decade transfer is 5·7 milliseconds to which must be added 0·57 milliseconds for every decade transferred. The average access time for a channel transfer is only 0·28 milliseconds to which must be added 11·45 milliseconds

for the actual transfer; a channel transfer takes a maximum of 12 milliseconds.

Decades and channels are numbered from 0 upwards regardless of the number of drums. Transfers are not affected if a decade transfer should involve different drums.

In addition to the 12,000 words on each drum there are two "reserve" channels of 200 words each which are used to hold special programs such as engineering test routines. Information may be read from these channels as from other channels but they are protected from being overwritten except by manual intervention by the engineer.

Arithmetic Unit

The machine operates in a serial-parallel mode. The fast arithmetic unit consists basically of three registers, A, B and C, which are connected individually and via the mill. Register A is used as the link between the core store and the arithmetic unit and is also connected with the program controller. Arithmetic and logical operations normally use register B which is also used for output to the printer and punch. Results of functions using register B may either be left in register B or placed in the core store. Register C is primarily used for card input but is also used in multiplication. Input and output for magnetic tape is directly to or from the core store.

The program is obeyed sequentially from the core store. One word normally holds two instructions and, as each word is transfered to the program controller via register A, the function in the most significant half of the word is obeyed followed by the function in the least significant half. To transfer each pair of instructions to the program controller takes 12 microseconds and some typical function times are listed below:

Addition—leaving result in register B	..21 microseconds
Addition—leaving result in core store	..25 microseconds
Logical operation	..21 microseconds
Test	..12 microseconds
Multiplication	..average 175 microseconds per digit in the multiplier.

The arithmetic unit will operate automatically in decimal or sterling, the pence position being variable within each individual word. All core store transfers are checked for parity and a check sum is applied to each word during drum transfers.

Card Reader

The card reader, operating at a speed of 600 cards per minute, consists only, apart from the actual sensing, of a decoding mesh.

Cards are fed endwise, face down, column 80 leading and pass two sets of photo-electric cells (3 cols. apart) in their movement from hopper to stacker. The hopper may hold up to 2,000 cards and there are two stackers—one with a capacity of 2,000 cards, the other with a capacity of 500 cards—and selection of stacker is under program control.

The first set of photo-electric cells encountered are the reading cells and the second set the check reading cells. Register C is used as the input register and is loaded with the zone and numeric components of three columns from each set of cells. The comparison of readings from the two sensing stations is carried out by program.

Line Printer

The line printer operates at speeds up to 600 lines a minute, there being 120 print positions per line and 50 characters per print position. Characters are spaced at ten to the inch horizontally and six to the inch vertically.

Each print position has its own "wheel" of 50 characters and 120 of these wheels are bonded together to form a print "barrel" which is continuously revolving at 800 r.p.m.

Printing is controlled entirely by program and pulses are sent to the required print positions as each character passes the hammers. These pulses are sent to the printer direct from register B and a check is carried out, by program and by using indicators set by the printer, that pulses have been sent at the correct time.

Paper throwing is also controlled by program. When throwing at full speed the paper travels at 2·1 milliseconds per line. A sheet marker is provided to ensure the correct positioning of each new form to be printed.

Achievable printing speeds are dependent on the type of job being processed but, as a guide, direct listing from cards is carried out at 570 fully printed lines per minute.

Card Punch

Cards are punched at the rate of 100 per minute. Pulses are sent from register B to the punch knives in the same way as for the printer. The punching is read back into the computer by means of a reading station and checking of the information actually punched, against that giving rise to the punching, is carried out by program.

The hopper has a capacity of 800 cards and the stacker 650 cards. Cards may be offset in the stacker by program.

Magnetic Tape

Magnetic tape facilities on the machine require the addition of a magnetic tape control unit plus up to 8 tape transports. Tape may be read and written simultaneously but only one operation of each type can be carried out at the same time.

Transfer of data from tape to core store and from core store to tape is effected by means of an automatic interrupt facility. As each word is read from the tape, the tape unit requires access to the computer and the program currently being obeyed is interrupted while this access occurs. When writing, the program is interrupted when a word is ready to be written on to tape.

Each transport may be individually numbered for reference by the computer. A queuing system operates whereby, when processing a large file, any two successive reels of the file may be placed on two different transports; the transports are assigned the same number and the "Operate" button pressed on each transport in the required sequence. On starting the job reel 1 will be processed and, as soon as the rewind order is given for that reel, work will be commenced on reel 2. Thus while reel 2 is being processed reel 1 may be rewound and replaced with reel 3.

The reel length is 3,600 ft. and the block length is variable.

When writing, information written on to tape is immediately read back for checking. A powerful system of checking is used such that when tape is read any single bit errors are automatically corrected and any double bit errors are detected, for each lateral position or "frame" across the tape. This ensures in the vast majority of cases no loss of time, and requires no programming effort.

The preceding points apply to both the two alternative magnetic tape systems which may be used with the 1301, their different characteristics being set out below.

The High Speed Magnetic Tape System

With this system the automatic interrupt facility interrupts the program for 15 microseconds every 133 microseconds. The tape is 1 in. wide with 16 tracks. Packing density is 600 decimal digits to the inch and the tape speed is 150 in. a second giving a rate of 90,000 decimal digits a second. A fast rewind of 225 ins. a second is provided. The stop time is 2·65 milliseconds, the start time 2·9 milliseconds and the inter-block gap when the tape is stop-started when writing is 0·935 in. If a read or write order is given within 0·533 milliseconds of the completion of a block, continuous processing will be maintained; in such a case the inter-block gap on writing is reduced to 0·7 ins. When reading, the tape may be stop-started in the minimum gap of 0·7 in.

The Standard Magnetic Tape System

With the standard system the automatic interrupt facility interrupts the program for 15 microseconds every 533 microseconds. The tape is ½ in. wide with 10 tracks, packing density is 300 digits to the inch and the tape speed is 75 in./sec., giving a rate of 22,500 decimal digits per second. In all other respects this system is compatible with the High Speed System.

Programming

A single address system is used with a comprehensive range of functions including some special functions connected with the input/output units. Two digits are used for the function and four for the address. Thus two instructions may generally be held in each word. The exceptions to this are drum transfer and magnetic tape read and write instructions which are double length and occupy one word each.

A large range of testable indicators are available which may be divided into four main groups:

(*a*) Those which may be set by program.
(*b*) Those which may be set by manual switches on the console.
(*c*) Those which are set to record the state of numbers leaving the arithmetic unit.
(*d*) Those which are set by various conditions in the peripheral units.

Programs in machine language are normally written in blocks which are convenient sections of the whole routine. Each block of program is assigned a block number which is used as a relative address. It is therefore easy for different programmers to write different sections of the routine, merely referring to data or instructions in another block by the appropriate relative address. The various sections of program, when completed, are punched on to cards, as are the relative addresses. When all cards have been punched the whole pack is fed into the machine which, by means of a special program stored on one of the reserve channels of the drum, will translate all the relative addresses into absolute addresses, store the result on the drum and set the machine ready to start obeying the program.

Owing to the manner in which the program controller works the problem of incorporating a sub-routine in a main program is very straightforward—the program controller providing the link which will return control to the main program either to the next instruction or to any other desired point.

A large variety of sub-routines are available and these include, in particular, programs for operating the peripheral equipment. By using the technique of time-sharing the card reader, card punch, line printer and magnetic tape units are made to operate simultaneously. Alternatively, main program may be time-shared with, say, operation of the printer and punch—or any other combination. This enables the fast internal speed of the 1301 to be utilised at all times.

Costs of Typical Installations	£'s
Basic machine	65,000
Card machine with 4 drums and 800 words of core store	94,000
Machine with 1 drum, 400 words of core store and 3 magnetic tape units using the standard system	110,000
Machine with 1 drum, 1,200 words of core store and 5 magnetic tape units using the standard system	146,000
Machine with 1 drum, 2,000 words of core store and 5 magnetic tape units using the high speed system	204,000

Rental terms are also available

FERRANTI COMPUTER FOR AIR TRAFFIC CONTROL

The main problem facing civil air transport today on the Atlantic routes is the ever-increasing number of piston-engined aircraft and the rapid introduction of jet aircraft requiring different control techniques, both factors combining to aggravate potential hazards. This brings with it the attendant problem that as the numbers of aircraft increase, so the volume of work for controllers increases proportionately.

Experimentation has been carried out in order to find a solution to the more efficient use of air space by investigating new control techniques and the possibility of using smaller separation standards between aircraft. It was also felt that the use of the computer could ease the manpower problem as it would free the controller from a number of time-consuming routine tasks.

Ferranti Ltd. now announce that their APOLLO computer, the first of its type ever to be used for air traffic control experiments in this country, will go into operation at the Scottish air traffic control centre at Redbrae, Prestwick, early in the spring of next year. Initiated by the Ministry of Aviation, this development represents a significant advance in the application of data-processing to the control of air traffic.

The new high-speed, transistorised, parallel computer, which is at present under construction at the Company's computer research establishment at Bracknell, Berkshire, will be used for processing flight information, but initially this will be done only on an experimental basis.

The Problem

Aircraft flying the North Atlantic are subject to rigid traffic regulations. Whether flying eastbound or westbound, each aircraft must conform to agreed separation standards, which are 30 minutes' longitudinal flying time between aircraft, 2° of latitude and 1,000 or 2,000 ft. in height, according to the flight level.

To prevent possible collisions, as there may be as many as 100 aircraft in the sky at once, it is the oceanic controllers' job to be fully aware of traffic conditions and to re-route aircraft, should it be necessary, to avoid infringement of separation standards.

For this purpose, careful attention is paid to pre-flight planning and the present practice is for pilots to submit a flight plan some time before the proposed departure time.

Flight progress strips are then prepared for use on the controllers' flight progress boards. These strips contain such information as the aircraft identification number, aircraft type, point of departure, departure time, destination, cruising speed and altitude, longitude and estimated time of arrival at specified meridians. Radio contact is also maintained between the aircraft in flight and the control centre, so that position reports giving time, altitude and latitude at the meridian just crossed and estimates for the next meridian, can be verbally reported by the pilot. In this way the controller is able to keep an up-to-date detailed record of the route and position of each aircraft, in the form of flight progress strips, which enables him to make control decisions.

The whole process of sorting out information, amending flight progress strips and guarding against infringements of the regulations is carried out manually by the controller.

The Apollo Computer

The new computer, which has taken two years to develop, will print out flight progress strips relating to each aircraft and provide up-to-the-minute information on air traffic conditions. It will also carry out calculations to see whether aircraft are in conflict and, if it is found that separation standards are being infringed, details of this will be printed out for the benefit of the controller who retains the basic responsibility of re-routing the aircraft. The complete situation may also be shown pictorially to the controller.

The computer, which works in real time, consists basically of three cabinets, each 6 ft. high, 22 in. wide and 19 in. deep. Positioned alongside the computer is a table upon which is mounted a number of Creed 25 tape punches and in front of the computer is the control desk upon which is mounted a Ferranti TR5 tape reader and a Creed 75 printer. A fourth cabinet contains electronic equipment developed by the Ministry of Aviation in conjunction with *RRE* for cathode-ray tube displays. Each cabinet is equipped with cooling fans. Power consumption of the complete equipment is about 2 kilowatts.

It employs magnetic core stores of 4,096 words capacity for programming and 4,096 words for data, with cycle times of the order of 6 microseconds.

Typical examples of instruction times are: simple orders, 6 or 8 microseconds; shifts, multiplication, division, up to 60 microseconds. When completed, this computer will be one of the fastest in operation in Britain. The word length is 24 binary digits, which will be used in three ways: (i) Binary number with sign. (ii) Four six-bit characters. (iii) Instruction.

The System

For processing flight information, the computer receives data from the local operators via four Creed 75 printers with keyboards. Under the new system, the operators will receive the same information as the controller now receives. This information will be sorted out in conjunction with a controller and only relevant information will be passed to the buffer store of the computer. At the same time, a record of what has been typed appears on the printer associated with the keyboard, and if the operator is satisfied that everything is in order, he then presses a key on the keyboard indicating to the computer to transfer the information into the main file.

Depending on the message, certain stored programs are brought into action and data is processed and checked for conflict. If the information concerns a flight plan it is stored until the departure time is received. This information is then processed and flight progress strips are printed out automatically on Creed 75 printers. This is done according to a time criterion, which enables the strips to be entered on a board in readiness for the entrance of an aircraft into the controlled area.

There are four Creed 75 printers with functional keyboards, one for use by each controller, enabling them to make requests

to the computer, such as asking for flight strips before they are printed out or any other relevant information. The Creed 75 printers have been developed by the manufacturer in conjunction with *Ferranti Ltd.* to transmit and receive parallel code signals. Two Creed 25 paper tape punches are employed for data output which is then analysed for functions of air traffic control.

Communication Developments

Provision is made for information to be transmitted over normal serial teleprinter lines from a remote source directly to the computer memory via a converter unit. New information can therefore be inserted into the computer memory at will from other control centres.

In the air traffic control system planned for the future, information such as this could emanate directly from other computers and in this way the task of processing flight information could be shared by air traffic control centres throughout the country. Other manufacturers are also developing machines for air traffic control in the future, and it will be interesting to see how the *Ferranti* experiment progresses.

NEWS FROM MANUFACTURERS

Data Collection

Computers can only use their great speed and decision-making ability to process data, after the data has been collected and converted into the right media. It has often been said that input to computers should be set up as an automatic by-product of some other earlier operation—and this is especially true of factory and retail shop data. There is now news of three systems that seek to perform this vital step.

In the DU-OP range of equipment manufactured by *Industrial Accountancy Partnership Ltd.*, the data is printed by the DU-OP Recorder which also punches the same information (and certain additional data) on paper tape. The roll of tape is then converted by special equipment into whatever medium and code is required—punched cards, punched tape or magnetic tape.

The DU-OP system has been installed in a number of retail Co-operative Societies and it is intended to adopt the system to hire purchase accounting, job costing and stores control. A new factory is being built in Ireland to produce the DU-OP machines.

The IBM 357 Data Collection system consists of reporting stations on the production line, which transmit to a central processing point information about work-in-progress. Pre-punched cards are inserted by the employee into an input station, and a punched card is produced automatically at the computer centre. The input stations are similar in size and appearance to a time-clock, and additional information not in the pre-punched card can be sent by means of a keyboard attached to the station. The time can be automatically punched into the output card.

The IBM 357 system has been used in the USA at the *Boeing Air Company* to provide up-to-the-minute information on progress in all areas of the factory. Information is available on where an order stands at any moment, the stage of each component or sub-assembly, and which machines are in operation or temporarily out of action.

ICT Limited had on show at The Production Exhibition at Olympia in April a performance recording system for use in factory and plant control. This equipment designed and produced by the Special Projects section of *ICT* can be attached to any number of machines. It can provide automatically and continuously at a central location, details of output, total idle time per machine per shift, causes of stoppages and the order number on which each machine is working. The recording systems are "tailor-made" for each customer and *ICT* state that machine utilisation can be improved so as to pay for the cost of the system, as well as producing as a by-product the media for data processing.

IBM 7080

The new *IBM* 7080 data processing system, a transistorised development of the *IBM* 705, can process work up to six times as fast as any previous *IBM* commercial computer, yet at a substantially lower job cost.

Addition on the 7080 takes 12 microseconds and the average multiplication 140 microseconds. The system can read and write from up to five independent magnetic tapes simultaneously, each at the rate of 62,500 characters per second and, at the same time, perform internal computation and the transfer of data.

The main storage of the 7080 consists of up to two units of magnetic core storage (each with an access time of 2·18 microseconds) which together can hold 160,000 characters of information. In addition there is an auxiliary storage of 1,024 positions, with an access time of 1·09 microseconds. Card readers, punches and printers for the 705 can be used with the 7080, together with up to 50 magnetic tape units.

The new system requires only 50% of the air conditioning and power of the 705 and 30% less space, and further reductions in space can be achieved by using the *IBM* 1401 data processing system for off-line printing.

Large EMI Computer for Ministry of Pensions

An order for one of the largest electronic computer installations in Europe has been placed with *EMI Electronics Ltd.* by the Ministry of Pensions and National Insurance.

The computer, an all-transistor EMIDEC 2400, will cost over half a million pounds to manufacture and install. The computing centre will be set up at the Ministry's Newcastle establishment to deal with the huge volume of data processing connected with the new Graduated Pensions Scheme.

It has been calculated that there are some 25,000,000 insured persons, with over a million additions or changes each year. The computer will "store" full statistics such as name and address, amount of each contribution and sum paid to date of each insured person. Each day, the records of every insured man and woman in the United Kingdom will be processed in order to extract the required information for persons reaching retirement age, and other changes in personal particulars. The computer is capable of completing this task in under four hours.

The number of forms which will have to be processed yearly to enable the scheme to operate at top efficiency will total over 30,000,000.

The EMIDEC 2400 will use nineteen EMIDATA fast start-stop decks designed by *EMI*. To speed the flow of information from the computer, a new type of printer capable of producing 3,000 lines a minute will be used. All plug and socket connections will be gold-plated in order to ensure absolute reliability.

The EMIDEC 2400 is an advanced general-purpose high-speed computer designed for a wide range of applications in the data processing field.

Many operations such as input, output and computing, proceed in parallel by means of a time sharing system which makes maximum use of the high speed of the central computer. A versatile program interrupt feature allows a large installation with many peripheral units to be automatically program-controlled.

709 for CEGB

The Central Electricity Generating Board has ordered an IBM 709 data processing system including 12 magnetic tape units, to be installed in their London offices in 1960. It will be used mainly for calculations in connection with the design of nuclear reactors.

The system for the Central Electricity Generating Board is the second 709 to be installed in the UK, the first having been at work with the United Kingdom Atomic Energy Authority since last year.

British Sales in USA

An agreement has been signed between *EMI Ltd.* and the *Fairbanks Whitney Corporation* of New York.

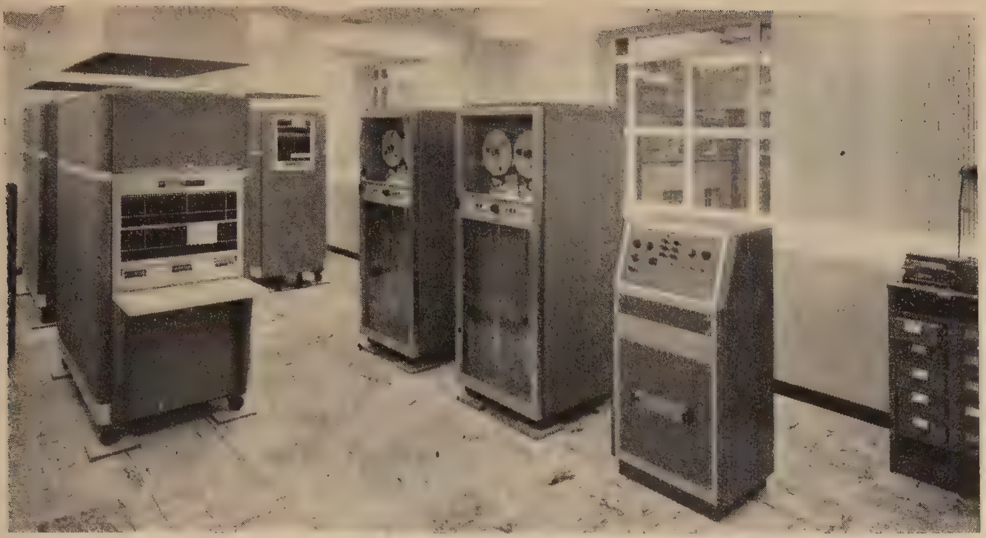
Under the agreement the *Fairbanks Whitney Corporation*, whose Group manufactures products ranging from machine tools and diesel electric locomotives to aircraft engine accessories and missile components, undertakes to market *EMI* products such as the *EMIDEC* computers, analogue computers, scientific and industrial instruments, electronic control and automation systems, and closed-circuit television.

Mr. Clifford Metcalfe, C.B.E., Managing Director of *EMI Electronics Ltd.* said: "We are confident that backed by the nation-wide sales organisation of *Fairbanks Whitney*, our products will make a tremendous impact on the USA market.

"We are also going to study the possibility of a joint venture in the electronics field in the European Common Market."

Implementation of the agreement will begin in 1960 with the installation in the Beloit, Wisconsin, plant of *Fairbanks Morse and Co.*, and the *Pratt and Whitney Co.* plant at West Hartford, Connecticut, of two EMIDEC 1100 electronic computers. They will be used to serve these two large industrial installations for both engineering and business data processing and will also provide demonstration units for the United States market.

New giant EMIDEC 2400 Computer takes shape



ERIC, showing the Console Unit, two Tape Units and the Tape Control Unit

LCC Install ERIC

On 12 April, London County Council formally opened their installation of an *IBM* 650 computer at County Hall. The machine is known as ERIC (Electronic Recording and Integrating Computer) and will be used first of all for the monthly salaries of about 10,000 staff and pensions for nearly 12,000. The remaining payroll, costing and stores work will be taken on in stages over the next two or three years, followed by accounting and statistical operations.

The 650 installation which includes two 727 magnetic tape units, a tape control unit, a sterling conversion unit, and a 407 accounting machine (tabulator) is rented for £60,000 a year. This rental covers machines, training and maintenance. In addition the installation of the equipment and its air-conditioning plant cost £30,000. Despite this fairly heavy figure it is estimated that by 1965 the installation will have paid for itself and will be showing a net saving of some £30,000 a year.

The details of the electricity supply and air conditioning are worth considering.. The computer system at present has a total load of approximately 45 kVA which may be increased to 60 kVA. In addition certain ancillary machines such as sorters, interpreters and collaters require approximately 15 kVA.

The equipment is supplied with electricity by means of cables rising from the ring-main distribution system in the sub-basement of County Hall connected to a 415/240 volt supply. A separate cable has been used for the computer to isolate it from the small voltage fluctuations which are bound to arise.

The range of conditions within which the computer equipment will operate is 50° to 90° F, 20% to 80% relative humidity and an air filtration of 99·9% down to 5 microns. Owing to the large heat emission the air conditioning plant has been designed to give comfort to the operators and to maintain an average of 70° F and 55% relative humidity. Because it is very noisy the refrigerating plant and air compressors are housed in a sub-basement remote from offices; the rest of the air conditioning plant is, however, on the fourth floor next to the computer room. The plant filters, washes, humidifies, cools (or warms) and delivers about 8,000 cu. ft. of air a minute to the computer room. The duplicated refrigerating plant and pumps (to give reliability) have a combined rated output equivalent to freezing 26 tons of water to ice every 24 hours.

Computer for Dorman Long

An order has been placed by *Dorman Long (Steel) Ltd.* with *IBM* United Kingdom Limited for an *IBM* 305 RAMAC computer, to be used in the mill order office for acknowledging customers' orders, production control and invoicing. Initial research into the question of using a computer for such work was carried out by the *British Iron and Steel Research Association*, as a result of which a number of computer manufacturers investigated the application of their systems in the *Dorman Long* mill order office. The RAMAC met the need for quick access to stored information.

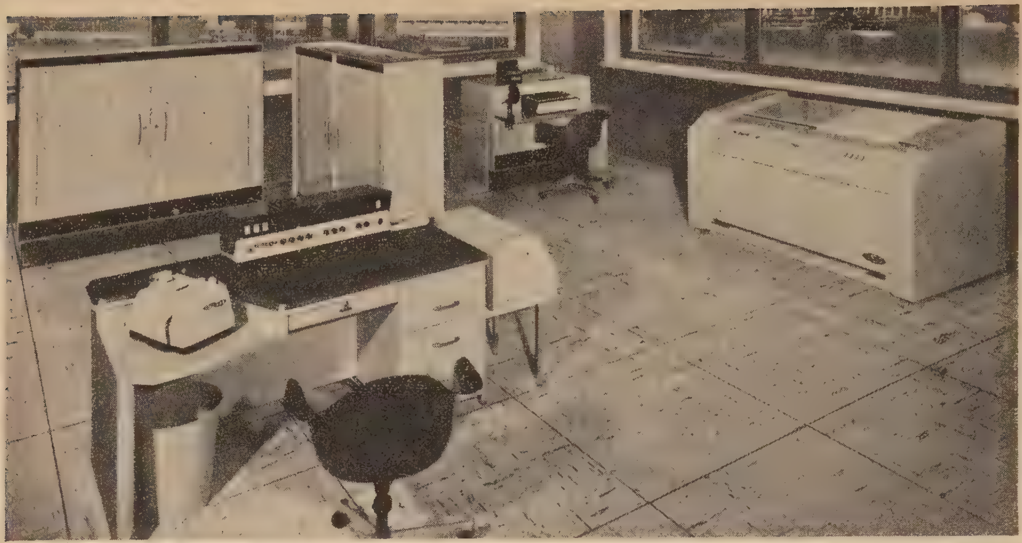
Central Programming Service for ICT

ICT have now created a Central Programming Service to bring together all programmers in the company, and Mr. Peter Ellis has been appointed Manager. He will report to the Manager of the Computer Group, Mr. L. Lightstone.

ICT is organised in several functional Divisions such as Production, Research and Design, Sales, Planning, Personnel and Training, Finance, etc. In the past it has been necessary to include in most of these Divisions a number of programmers to serve the particular needs of each Division.

The C.P.S. has been created to make the best possible use of the considerable number of programmers now within *ICT*, and to enhance the career prospects and employment of each individual programmer. It will also shorten the time between conception and realisation of new computing systems.

The whole Computer Group, including the Central Programming Service, is moving from a number of different offices throughout London to a new building of 34,000 sq. ft. at Putney. This building will be the *ICT* Computer Centre and will house a number of the company's latest computers.



Panellit ISI 609 System

Process Control

The photograph shows a typical installation of a Panellit ISI 609 Industrial Information and Computing System manufactured by *Panellit Limited*, a member of the *Elliott-Automation* Group. The major items of equipment shown are, at the rear, the two control cabinets, one of which houses the Elliott 803 computer and the other the selection and measuring equipment, with, in the far corner, the computer control desk. In the foreground is the Plant Operator's Control Position and on the right of the picture the cabinet containing a large electric typewriter for recording information.

The 609 is a powerful industrial control system which carries out continuously a number of functions. It scans measurements, received in the form of electrical signals, from up to a thousand or more points and checks that they are at the required levels, giving warning of any dangerous conditions or variation in efficiency. A printed record is given of all the conditions in the plant at regular intervals. The efficiency of the operation of selected sections of the plant, or of the plant as a whole, is calculated, and Management is provided with the information necessary to enable it to operate the plant at its most efficient level. This same information can also be used for the direct automatic control of the plant.

MSS Recording Co. Ltd.

The *MSS Recording Company* has made a study of the performance of Data Processing Tape in relation to the occurrence of dropouts. They have found that an analysis of the results of a specially designed system of dropout tests will enable the performance of a particular batch of tapes to be stated for a very wide range of conditions of use. The information enables the computer time lost in error correction to be estimated and its cost to be weighed against the cost of any proposed grade of tape.

The tests also produce information which is of great value to the designer and the user of Data Processing Systems since it enables them to predict the effect of changes in pulse packing density or dropout level on the performance of their system.

The equipment which has been developed for carrying out these tests was shown on the *MSS* Stand at the *IEA* Exhibition at Olympia, 23–28 May, 1960.

BRADFORD SYMPOSIUM

A symposium entitled "Computers—their use and Control", was held at the Bradford Institute of Technology from 25 April to 29 April, 1960. It was organised jointly by the Mathematics Department of the Institute and the Information Processing Division of *Standard Telephones and Cables Limited.* The object of the symposium was not only to indicate the applications of a computer but also to encourage the delegates to program their own problems. A basic STANTEC-ZEBRA computer with additional input and output facilities was installed at the Institute for use by them.

Invitations were accepted by about eighty of the managerial staff of local industries, commercial organisations and educational institutions. Many who were unable to attend the symposium beyond the first day, which was complete in itself, sent their technical representatives on the subsequent days.

Proceedings on the first day were initiated under the Chairmanship of Alderman Revis Barber followed by the opening address given by Dr. E. D. Edwards, Principal of the Bradford Institute of Technology. Mr. K. A. F. Frost, the manager of the electronic system group of *Standard Telephones and Cables*, gave a talk entitled "Introduction to Computers" and Dr. R. J. Ord-Smith, Head of the Programming Department of *Standard Telephones and Cables Ltd.*, spoke about "Computer applications and basic block diagrams." During the afternoon of the first day, demonstrations were arranged on the STANTEC-ZEBRA digital computer and the Institute's EMIAC II analogue machine.

On subsequent days delegates were able to use the computer themselves and were taught enough programming to enable them to run some of their own problems on the machine.

Thursday and Friday were devoted to more detailed programming and on these days the computer was available for running more comprehensive programs. It has been left at the Institute for this purpose and for their own use.

Similar symposia are being arranged by *Standard Telephones and Cables* in collaboration with other Colleges of Technology, the next to be held at the Leicester College of Technology and Commerce from 18 July to 22 July, 1960.

THE BRITISH COMPUTER SOCIETY LIMITED

ANNUAL REPORT, 1959–60

The Society has again had a successful year and its financial position has considerably improved. This report formally covers the financial year ending 30 April 1960, but the opportunity is taken to mention events of general interest which have occurred during the first three months of the new financial year.

Membership

The membership of the Society has continued to expand, as is shown by the following figures:

Membership:	*30 April 1960*	*30 April 1959*	*30 April 1958*
Ordinary	1,850	1,687	1,182
Institutional	113	89	38
Associate	151	125	80
Student	4	2	—
	2,118	1,903	1,300

During the year 416 new members were admitted, 123 members formally resigned and 82 were struck off the register, under Article 62, as their subscriptions had remained unpaid.

Finance

The Income and Expenditure Account for the year ended 30 April 1960 and the Balance Sheet at that date are given on pages 48 and 49.

During the first two years of the Society, considerable difficulty was experienced due to lack of working capital. As stated in the Annual Report for 1958–59, Council therefore decided on a reorganisation of the office, leaving a not inconsiderable part of the administrative work in the hands of the honorary officers. This policy of retrenchment and consolidation was continued during last year and has resulted in a surplus of income over expenditure of £2,902, due in part to the excellent work done by members of the Cambridge University Mathematical Laboratory and honorary officers in the organisation of our First Conference. The grant of £500 from the EEA/OABETA Computer Exhibition and Symposium (1958) Committee provided a further substantial strengthening of the Society's financial position, for which Council is deeply grateful.

Having achieved this satisfactory financial position, Council will now consider how best it can take advantage of this strengthened position to further the interests of members of the Society.

London Meetings

Fourteen meetings were held in London during the period from September 1959 to May 1960. Attendances were satisfactory, ranging from 50 to over 200. The series opened with a brains trust, and included

4 meetings on operating experience with business installations, 3 of which were overseas;

2 meetings on new machines, one British and one French;

2 meetings on analogue computer techniques, one of which was a full day meeting attracting 150 people;

2 meetings on simulation techniques;

1 afternoon meeting on new computer elements;

2 meetings which dealt with fringe subjects, the human brain as a computer, and the broader aspects of automation, which were well attended.

Most of the London meetings have been held at the Northampton College of Advanced Technology, and the Society records its thanks to the Principal and the Head of the Mathematics Department, for the accommodation and other facilities provided.

In association with the Institution of Electrical Engineers, the Society organised a two-day discussion meeting on managerial and engineering aspects of reliability and maintenance of digital computer systems under the aegis of The British Conference on Automation and Computation. Council acknowledges the very considerable help of the I.E.E. in providing the halls and detailed organisation and in arranging for the subsequent publication of the *Proceedings*.

The Meetings Committee would at all times welcome offers of papers and suggestions for future meetings and information about intending overseas visitors, who may be prepared to address the Society.

London Study Groups

Discussion groups were successfully operated on 8 of the 16 subjects offered, and were supported by 255 members, a quarter of those residing in the London area. The subjects were:

Input and Output.	Feasibility Study.
Operational Experience.	Advanced Programming.
Production Control.	Scheduling and Stores Control.
Operational Research.	Statistics.

Seven of these groups are anxious to continue next year and several have programmes already planned. New members will be welcomed to these, and also to the Numerical Analysis group, which is just being formed, and will commence meetings during September. A survey of the members of Study Groups has been carried out, which shows that a new type of activity proposed by the Study Group Chairman would be welcomed. The proposal is to have a half-day or a full-day session on a particular subject, which would be introduced by an informal lecture posing any controversial issues. The meetings would then be divided into small discussion groups and the chairmen of these would report the result to a closing session.

Visits to computer installations arranged by the Society have been welcomed and were well supported by Study Group members.

Publications

The labour dispute in the British printing industry, which began in July 1959, delayed publication of *The Computer Journal* and *The Computer Bulletin*; the opportunity was taken to review the publication dates when work was resumed at the printers.

As a result of this, Council decided to enlarge and change the frequency of publication of *The Computer Bulletin* from bi-monthly to quarterly. In future, *The Computer Journal* will appear quarterly in the months of April, July, October and January; *The Computer Bulletin* will appear in June, September, December and March.

The circulation of publications outside the Society has increased:

	1960	*1959*
Subscribers:	*June–July*	*April*
Journal	607	514
Bulletin	239	169

The support of manufacturers, who advertise regularly, is acknowledged.

The editorial work on the Society's publications is carried out entirely by its honorary officers. They are dependent for notices and reports of Branch activities on honorary officers of regional branches; their efforts, which lead to reports of meetings or the submission of papers for publication, are gratefully acknowledged.

All the Society's publications have been maintained in print and back numbers may be purchased from the Society's office.

In April 1960, Council decided to co-operate with the Association for Computing Machinery in the preparation of abstracts for *Computing Reviews*, a new journal established in February 1960 under the direction of an Editorial Panel chaired by Dr. John W. Carr (University of North Carolina, past President of A.C.M.). A panel of 20 British reviewers has now been drawn up and the work originating in the U.K. will be co-ordinated by the Society's representative on the Computing Reviews Editorial Board, who is Dr. Andrew D. Booth (Director of the Department of Numerical Automation, Birkbeck College, W.C.1).

Computing Reviews is at present published as part of *Communications of the A.C.M.* Members of the B.C.S. may subscribe through the Society's office, at a reduced rate of £1 9s. 0d. per annum, to *A.C.M. Journal* and *Communications*.

Annual Prizes

The Committee has considered 47 papers that appeared in *The Computer Journal* and *The Computer Bulletin* between April 1959 and April 1960. The two prizes of 20 guineas each will be awarded at the Annual General Meeting. The marking scheme has been to consider the papers under five headings:

(*a*) Importance of subject.
(*b*) Originality of work or approach.
(*c*) Critical appreciation of related work.
(*d*) Clarity of exposition.
(*e*) General quality of summary, introduction and conclusion.

It is hoped that the prize scheme will stimulate a steady flow of papers in the future on both scientific and business topics.

Second Conference (Harrogate)

The Society's second annual conference was held at Harrogate from 4–7 July. Some 400 delegates from Great Britain and Overseas were registered.

The conference was opened by an address from the President in which he reviewed the work and role of the Society and 30 papers were presented at 9 sessions with the following themes:

Progress towards a common language for computers.
The use of computers in market research and statistical analysis.
The role of small computers in science and industry.
The state of the art in U.S.S.R. and U.S.A.
The organisation of a computing centre.
Simulation studies in process control and planning.
Numerical analysis.
Large-scale data processing in Government departments.
Accounting applications.

The conference was voted a great success by all those taking part. Outside the official activities, the enjoyment was enhanced by the facilities offered by Harrogate Corporation, and by the agreeable surroundings of the conference hall. Council has recorded its appreciation of the considerable work done by honorary officers and voluntary helpers in organising the conference and the exhibition of equipment in which 12 manufacturers participated.

Visits were organised to four local computer installations, by courtesy of the organisations operating them.

(A detailed report will be published soon—Ed.)

International Federation of Information Processing Societies

The Federation was formed on 1 January 1960 following informal discussions in which the Society was represented at Paris in June 1959. Fifteen national societies have adhered to the statutes. The President, Dr. M. V. Wilkes, F.R.S., represented the Society at the first meeting of the Council of the Federation held at Rome in June 1960.

The first President of I.F.I.P.S. is Mr. Isaac L. Auerbach, who represents the Joint Computer Committee of A.C.M., I.E.E. and I.R.E. of U.S.A. The Vice-President is Professor Dr. A. Walther of the Deutsche Arbeitsgemeinschaft für Rechenanlagen.

It is expected that a second international conference will be held in Munich early in September 1962.

Education Committee

The Education Committee has considered the facilities at present available and possible syllabuses for future training of computer personnel, particularly operators, programmers and maintenance staff.

Consideration has also been given to the possibility of providing an Examination to form a qualification for operators and programmers. Informal approaches have been made to other examination bodies which are interested in this field and a further report will be made when a definite decision has been taken.

Committees on Automatic Programming

The Scientific Programming Committee has met regularly and has continued to publish suggested programming conventions in *The Computer Bulletin*. Particular attention has been given this year to the use of subroutines. On the Committee's recommendation, the Society supported the Algol project, and a member of the Committee was among those who met in January to formulate Algol 60. This language and others have been kept under review.

The Committee on Automatic Coding for Business Problems has concerned itself during 1959–60 with learning about existing source languages for business applications, rather than with trying to devise a new source language. As this subject is so new, it has been found difficult to find members who have the necessary knowledge to serve on the Committee, except from among those working for computer manufacturers.

During 1960–61 the sub-Committee hope to finish their study of existing systems and then to spend time considering the essential elements that should be incorporated into any automatic coding scheme for commercial applications.

Automatic Programming Information Centre, Brighton

Members of the two B.C.S. Committees are co-operating in the work of the Centre.

Glossary

The collaboration of the Glossary Committee with the British Standards Institution Sub-Committee on Computer Terminology continued throughout the period under review, and has resulted in a draft *Glossary of A.D.P. Terminology*. This is being edited during July and will be circulated by the B.S.I. Committee for comment in the Autumn under reference TLE/1/3. Meanwhile, the draft is being translated into other languages, to form the basis of a multi-lingual dictionary. Further information on these projects was given in the editorial of *The Computer Bulletin* for June 1960.

Specialist Group Committees

Business Group. The function of this Committee is that of an advisory group to the Society executive committees regarding the special interests of business members of the Society. It has made recommendations to the Study Group, Publications and Meetings Committees. A new Society activity, in the form of visits to, and study of, computer installations, grew out of a Business Group recommendation.

Scientific and Engineering Group. The Committee has been working with the Business Group Committee through a panel of representatives to organise the Study Groups of the Society, and visits to computer installations.

A number of recommendations relating to the establishment of formal qualifications for staff engaged in the running of computer installations were forwarded by the Committee for consideration by the Council and Education Committee of the Society. The Committee met four times during the course of the year.

Branch Activities

The following are some features of general interest in Branch reports:

Belfast. Several good meetings were held during the session, some of which related to general surveys of work already reported elsewhere. Lectures by Dr. A. D. Booth on "Computer Facts and Fallacies" and by Mr. C. Berners-Lee on "The Use of a Computer in Business Planning" attracted considerable local interest.

Birmingham. At the end of the year the Branch had seven institutional and 146 individual members. Eight meetings were held with a maximum attendance of 34 on two occasions. The policy of inviting visitors to meetings has led to a growing interest in the work of the Society. The study groups on general accounting and production control proved to be a valuable ground for exchanges of ideas and will be continued as discussion groups in 1960–61.

Bristol. This Branch was formed in November 1959 and 3 lectures have been held to stimulate interest in the district, covering general, commercial and scientific interests respectively. Attendances at these have been 60, 50 and 35 people, and each lecture was followed by brisk discussion. A further meeting was held on the 24th May at the University Engineering Department and a programme of 5 lectures is being prepared for next session.

Cardiff. Eight meetings were held with an average attendance of 32; one meeting took the form of a conducted visit to the computer installation of The Steel Company of Wales Ltd., which was well attended. The Branch has received five interesting lectures by representatives of computer manufacturers and two from users.

Glasgow. Attendance at the five meetings has averaged 25 including visitors, out of a Branch membership of 94. A

study group on stock control has held several meetings. In February, members of the Branch visited the Greenock factory of I.B.M United Kingdom Ltd.

Hull. The Branch committee has attempted to give members a varied programme and attendance averaged 25, with a maximum of 200. Visits have been made to computer installations in the district and the Society is taking a stand at the local exhibition concerned with education for electronics.

Leeds. Attendances at the 7 meetings varied between 9 and 20, from a total membership of 58. The programme covered production planning, banking applications, order handling, linear programming, simulation, and reports on conferences in Paris and Cambridge. Reminders were sent to each member before each meeting; in view of this, the committee feel that the response from members in attending the local meetings has been a little disappointing.

Leicester. Membership has increased from 24 to 33. Eight meetings have been held, of which two were joint meetings with local sections of the Royal Statistical Society and the British Productivity Association. A visit was made to the Leo installation of Stewarts and Lloyds Ltd., at Corby. The average attendance has been 18.

Liverpool. Seven lectures have been held with an average attendance of 20. A beginners' study group held 8 meetings with an average attendance of 12. Discussion groups have also met to consider production control, stock control and numerical analysis, the latter in co-operation with the Computer Laboratory at Liverpool University.

Manchester. Seven meetings were held with an attendance varying from 24 to 51. At the end of the year the Branch membership was 8 institutional and 116 individual members (an increase of 24 over 1959). Study group meetings were discontinued owing to lack of demand: beginners are well catered for in the district by organised courses.

Middlesbrough. Membership totals 34 individual and 1 institutional member. There are at least 3 electronic digital computers in the area and many firms are hiring computer time. Seven meetings were held and the subjects aroused much local interest.

Newcastle. Membership is now 55, 18 new members having joined during the year. Seven meetings were held. A commercial applications discussion section held 6 meetings which included 2 devoted to alternative methods of handling a problem on a HEC 1202 and a Pegasus computer.

On behalf of the Council,
F. YATES,
Chairman.

28 *July* 1960

Discarded Glossary Items

One Bit: The datum of amounts of data.

To Or: To perform the logical operation "or" on two inputs. Synonymous with "to orify". Note: To or is human. . . .

Half-Write Pulse: Salesman's term for a pulse which is half wrong.

G.T.

COMPUTER COMMENT

Specialised Seminars for Executives

International Computers and Tabulators Ltd. held during June a series of specialised one-day seminars to introduce higher executives in various professions and industries to the functioning and application of its new Type 1301 electronic digital computer which has a transistorised arithmetic unit.

For the insurance profession, four such meetings were held in London, Manchester and Edinburgh. They were attended by more than 80 senior officials from 50 different companies. At each meeting Mr. F. E. Ferguson, insurance computer specialist of *ICT*, outlined an insurance-systems model of the new computer and described how it could be used effectively in an office transacting all classes of business except marine insurance. The delegates were able to ask questions and discuss the solution of particular data-processing problems in their own firms.

For the steel industry, a one-day meeting was held at the Grand Hotel, Sheffield, and it was attended by 43 higher executives of the leading British steel manufacturers. At one of the sessions, under the chairmanship of Mr. F. J. Nash (Assistant Managing Director of *ICT*), specific data-processing problems arising in the steel firms were discussed and a team of specialists, conversant with the *ICT* 1301 computer and these problems, gave introductory talks and took part in the discussions.

The 1301 is a product of *ICT Ltd.* and *The General Electric Company Ltd.* In its design and development, the two companies have made use of their jointly-owned design and co-ordinating group, *Computer Developments Ltd.* of Kenton, Middlesex. Twelve orders were received, including three from overseas within a month of the announcement of the 1301 computer at the end of May.

Leicester Symposium 18–22 *July* 1960

D. W. Hooper gave the opening address at the Leicester College of Technology and Commerce. With his usual mastery of technical matters lucidly expressed in non-technical terms, he introduced the central theme "Computers" to an audience drawn from industry, commerce, local government, research and educational establishments.

Mr. R. E. Wood, the Principal of the College, had previously welcomed delegates and Mr. Hooper himself was introduced by Mr. R. L. Wessel, the well-known industrialist.

Subsequent lectures included one on Computer Applications by Dr. R. J. Ord-Smith, Head of the Programming Department of Standard Telephones and Cables Limited, and another on the Training of Computer Personnel in the Technical College by M. Bridger, Head of the Leicester College Department of Mathematics.

Early in the week delegates were programming their own problems in Simple Code on the STANTEC-ZEBRA computer installed at the College, and the machine is now available at the College for general and educational use.

PROBLEMS IN THE APPLICATION OF A COMPUTER TO WHOLESALE WAREHOUSE AND RETAIL BRANCH CONTROL

by J. W. Mitchell

This article is based on a paper given at The Second Conference of The British Computer Society at Harrogate on 7 July, 1960.

Introduction

Many problems arise when an attempt is made to install a computer in a commercial organisation. Processes which at first sight appear straightforward introduce unexpected complications when an attempt is made to perform them automatically. This paper is an attempt to show up some of the problems which do exist and ways in which they can possibly be overcome.

You will all be aware of the basic organisation and methods conception of investigation—the "What," "Why," "When," "Where," "Who" and "How." Whilst this is fundamental, you should never rely completely on your findings. It is a fact that you will always find at least three methods in existence—the method authorised by Management, the method employees think they use and, finally, the method actually employed. Unfortunately, a complete investigation of all three methods for the purposes of finding the solution as to what should be done and obtaining agreement from staff at all stages is not sufficient. Having completed the survey, you have all the information about what the staff wish you to think necessary—an entirely different matter from what actually prevails, as has often been forcibly impressed on teams attempting to install computers. The work having been programmed completely on the basis of information received, it is found that the system "falls down" on account of the presence of a multitude of not necessarily small points.

Exceptions to General Rule

In connection with one recent investigation in another company, all information pointed to the fact that the majority of ex-warehouse sales were made at the catalogue selling price, in a few cases special prices being quoted. Everybody agreed that no more than 5% of sales were at special prices. It was decided, in this instance, the special prices should be dealt with as credits: when invoices were being processed on the computer, the few specials could be extracted, and clerks could punch cards to enable credits to be produced. This was excellent, the Board were delighted, the warehouse managers agreed, the office managers concurred, and the buyers assented. The scheme, however, proved to be unworkable because, in actual fact, 95% of the sales were made at special prices; the salesmen had striven to conceal this fact, aided by the office staff. Clerks seldom referred to price-lists, because prices were usually on the orders which eased their work of invoicing.

As a result of this discovery, several months' patient investigation and planning had to be discarded and a new system evolved whereby the selling prices were fed into the computer along with order details, the computer then producing packing documents, delivery notes and invoices, as well as accumulating sales statistics, maintaining sales ledgers and stock records and preparing purchase requests, etc.

Preparation of Invoices Before Packing

The ideal system for a warehouse is one which makes provision for orders to be recorded on receipt. The computer can thus check the stock to ensure there is sufficient on hand, or due in, to meet the sales orders held. The day prior to despatch, packing notes can be prepared so that the warehouse can pack the goods and load them ready for delivery, and on the day on which delivery takes place the despatch note and invoice can be prepared, the former accompanying the goods and the latter being mailed to arrive the next morning. Thus, the delivery note can be a carbon copy of the invoice, without values inserted, thereby saving printing time (and costs connected therewith) on the computer.

This in theory is perfect. Goods are loaded the day prior to delivery, and your weekly routes covering all purchasers can be planned well in advance. The computer can, from the accumulated weights, allocate vehicles to the different routes according to the order situation—a wonderfully smooth system which should run automatically. Unfortunately, human nature being what it is, the program must deal with exceptions.

Delivery Programming

There is the customer who rings up on the day of delivery to cancel his order; he is relatively unimportant,

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the goods, if delivered, can always be returned for credit, and he can be informed that, unfortunately, the merchandise was despatched. But occasionally there is the urgent late order for goods which invariably accompanies a cancellation. These must be delivered, or you will tend to lose trade. There is also the customer who brings his order in and wishes to take part of it away with him. In both these instances, it is impossible to adhere to the normal procedure, and a means of quickly checking stock at any time is necessary; also, of producing packing instructions and ensuring that invoices can later be initiated in the computer without the danger of duplicate deliveries being made at later dates. In practice, this can be achieved without there being a necessity for random access storage of stock records, which would prove to be completely uneconomical in a warehouse carrying a large number of lines. It has been assumed that all deliveries will be made by wholesaler vehicle—but this is not necessarily true. In practice, many large customers will often arrange to collect their orders, usually at the same day and time. This can lead to complications in vehicle route planning and carriage charging, particularly where the customer's lorry is involved in an accident whilst on its way to collect the supplies, thus necessitating a rerouting of vehicles in order to deliver the extra load, and, undoubtedly, a revision of the carriage charge.

It should also be remembered that the transition of goods is not always via the warehouse. Perishable goods are often delivered direct from the dockside to the customer, which is also the case when a large number of orders is received for products from a particular manufacturer; also, goods are frequently delivered direct from the factory to the purchaser. The wholesaler still has to charge his customer and pay the supplier. This is particularly true in the bakery trade where wholesalers seldom carry any stock other than decorations and wrapping material, and arrange for the manufacturers to make bulk deliveries direct to the bakehouses, most of the trade being carried on by means of the telephone.

Fluctuating Market Prices

If one looks closely at the grocery trade, many small problems are discerned: for instance, purchasing often cannot be effected on a maximum/minimum stock level basis. Much of the firm's profit depends on their buyers' skill in purchasing when the price is right. Sugar and hams, for example, are subjected to unpredictable and rather violent fluctuation in market price, which state of affairs could prove upsetting, especially since the wholesaler must maintain supplies and try, as far as is possible, to keep his prices consistent, bearing in mind his competition. Many wholesalers claim that they always make a loss on sugar over the year but have to sell it to keep the rest of their trade. The buyer must be given a free hand to build up stocks when prices are low to provide a reserve to draw on when prices rise. Sugar refiners, however, frequently store sold sugar on behalf of their customers.

On the surface, selling prices would seem simply settled—goods are sold either by quantity or weight. Here, again, one quickly encounters difficulties. Some products are sold by quantity and priced by weight, and it is not always an easy task to relate weights to quantities. Cheese, for instance, dries up and loses weight whilst it is being stored, and can vary in weight considerably over the course of a couple of days. Then the cheese, when packaged, must be weighed for despatch, and the weights fed back into the system for the purposes of weight allocation and subsequent extension of invoices at so much per lb. The purchaser has no hesitation in claiming credit if he finds that the weights, on receipt, are a lb. out, as he also has to sell by weight to the public.

Knowledge of Earlier Orders

A further problem which is peculiar to this sort of trade is—"What Does the Customer Really Want?" An order will specify "Butter," or even "Best Butter." The warehouse stock some 50 or 60 makes and grades of butter. If the base order is fed into the computer—how will it know what to send? The chances are that the warehouseman knows which butter that particular customer normally requires and so can pack it, but you cannot practically classify all butter under one stock head, and then depend on the warehouseman to analyse orders, because sooner or later a request for a specific brand will be made, or the wrong brand will be packed in some special case. You will also need to overcome pricing difficulties. It is therefore essential for clerical staff to interpret the orders received, prior to the preparation of computer input media.

With regard to the drapery trade, problems are more in the nature of stock. Patterns are constantly changing and a large variety of colours and sizes has to be maintained. One corset manufacturer introduces a new line each month, having only six different lines in production at any one time. An even more bewildering array exists where socks and stockings are concerned; over 5,000 different sizes/pairs/patterns would not be unusual.

Discounts and Rebates

When ironmongery is considered, and in some aspects of the stationery trade, manufacturers' rebates become important. In some cases, rebates are allowed on increase in trade over the previous year, and in others they are based on the value of the trade in the current, or previous, year. Furthermore, all sorts of special rebates occur where, for instance, display cabinets are provided, and a rebate may be allowed for a sum not exceeding the value of the cabinet and the percentage of sales over a fixed period. Here the wholesaler must record, carefully, details of customers who are entitled to this consideration.

Re-Stocking of Retail Branches

One system which has been successfully used for dealing with greeting cards on a manual basis is where each stockist uses special display stands; greeting cards are on display and under each stand are cupboards containing reserve stocks. In connection with each line of stock, there is a re-order card printed with the customer's name and address, stock number and value, and an order for a quantity. When stock is depleted, the counter assistant removes the order card, which he then sends to the wholesaler. An invoice is made out from the card, and the card is sent into the warehouse (as packing instruction), where the goods are collected together with the card. At the despatch bay, all goods are checked against invoices and, when this is completed, then packed. The purchaser, on their receipt, checks the goods and places them in stock, retaining the card until he next wishes to order. The invoice is passed for payment. Thus, use being made of only one card, complete stock control (by purchaser) and warehouse control (by wholesaler) is maintained, the only document needing to be prepared being the invoice. When travellers bring round new lines, which are periodically introduced into the range, it is necessary to rubber-stamp the purchaser's name and address and insert the quantity on a pre-printed order card, which is sent into the warehouse (if it is desired that the line be stocked). If prepunched cards were used, this system could quickly be applied to a computer for work in connection with the warehouse, covering most small items sold; with regard to new lines, punching would take place when the order is received for the first time.

In connection with the boot and shoe trade, a move in the above direction has already taken place. The trade here is rather easier as, generally, a manufacturer has his own warehouse and chain of shops. A big problem, however, is stock control. Messrs. Hug, of Switzerland, have, to a large extent, overcome that problem by using punched cards (England, 1960). Punched cards are used to mark the manufacturing process and, in the computer, to adjust warehouse stock records; they are also used to record the transfer of stock from warehouse to branch shops, the cards accompanying the shoes to the shops (or wherever they are to be sold) and being returned to the computer centre where they are used once again for adjustment of stock records and checking of branch sales returns purposes. A stock check can be made at any time, as the shoes and un-returned cards from the shops must agree with the stock position recorded in the computer—a completely satisfactory check. It may be possible to use the cards as direct input to the tills.

The use of punched cards in this direction will undoubtedly increase, as there is now on the market a computer output unit which will punch cards and print up to 13 lines of 70 characters on both sides of the cards, thus providing both a printed record and computer input medium for the processing of information of this nature (the *Remington Rand* Card-Printing Punch, which can be used as an output device from the UNIVAC solid-state computer).

Cards are, however, not always suitable, and it is moreover not always necessary, or even desirable, to maintain completely detailed branch stock records. In the grocery trade it would be impracticable. Here, however, an alternative solution is available, for, by keeping branch stocks at selling price and charging branches at that price, complete control over all branches can be retained. A certain amount of subdivision is necessary, as branch managers must have power to exercise their discretion on certain lines. Perishable goods should be shown separately, as the manager may have to reduce prices, or even to throw away stock—his own responsibility; but for most ranges an accurate overall check on shops can be maintained. In all lines, however, the occasional "cut-price" week occurs. This may extend over all the retail branches in the group, or apply only to a few localised ones. In any case, this will of itself necessitate special consideration. As far as overheads, wages, etc., are concerned, these particular costs can, to a certain extent, be dealt with locally, the manager paying and reporting back weekly, or they can be dealt with and analysed by the computer. Whichever course is chosen, the branch records held on the computer should build up over the year to provide both branch and group accounts in as full detail as is necessary, providing overall control, particularly in connection with cash, and comparisons with the previous year or budget, printing out and querying major differences for investigation.

Conclusion

The object of the paper has been to stimulate thought and discussion in pointing out difficulties which are likely to arise in an installation. It is almost inevitable that small points will be overlooked when a system is planned, and it is indeed a wise man who knows his own business.

Reference:

ENGLAND, J. L. (1960). "*UCT* in Europe," *The Computer Bulletin*, Vol. 3, p. 79.

COMPUTER COURSES 1960–61

The Education Committee has received details of courses to be offered by educational institutes and the computer manufacturers.

It will be possible to give details of later courses in the next issue of the *Bulletin* if the information reaches the Editor by 28 October 1960.

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Computer Manufacturers

It has not proved possible to summarise the variety of courses offered. Much helpful literature is available and it is suggested that interested readers write to:

AEI Ltd.	K. C. Evans, Electronics Apparatus Division, Trafford Park, Manchester 17.
Bulmers (Calculators) Ltd.	A. R. Rider, 47–51 Worship Street, London, E.C.2.
Elliott Bros. (London) Ltd.	F. S. Ellis, Elstree Way, Borehamwood, Herts.
EMI Electronics Ltd.	J. W. Godfrey, Computer Division, Hayes, Middlesex.
English Electric Co. Ltd.	J. Boothroyd, Data Processing and Control Systems Division, Kidsgrove, Stoke-on-Trent, Staffs.
Ferranti, Ltd.	R. Wilkinson, 21 Portland Place, London, W.1.
IBM United Kingdom Ltd.	The Education Department, 101 Wigmore Street, London, W.1.
ICT Ltd.	F. A. Worsfold, Bradenham Manor, nr. High Wycombe, Bucks.
Leo Computers Ltd.	R. P. Gibson, Hartree House, 151A–159A Queensway, London, W.2.
National Cash Register Co. Ltd.	D. H. Triggs, 206–216 Marylebone Road, London, N.W.1.
Standard Telephones and Cables Ltd.	F. G. Filby, Information Processing Division, Corporation Road, Newport, Mon.

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Educational Institutes

Courses	*At*	*Commencing*	*Fee* £ s. d.	*Lectures or Sessions*	*Times*
Mercury Autocode	Manchester University	3 October	10 10 0	Full-time (3–7 October)	
Mercury Autocode	London University	10 October	5 0 0	(10–14 October)	11.00 a.m.–12.30 p.m. 2.00–3.30 p.m.
Mercury Autocode	Oxford University	11 January	7 10 0	Full time (11–13 January)	
Simplified Programming for Pegasus	Durham University	28 September		Full-time (28–30 September)	
Pegasus Programming	Durham University	14 November		Full-time (14–25 November	
Pegasus Programming	Southampton University	14 September	5 5 0	Full-time (14–23 September)	
Business Uses	Durham University	15 December		Full-time (15–16 December)	
Deuce Interpretive Scheme	Glasgow University	5 September	10 10 0	Full-time (5 days)	Repeated 10 Oct. & 24 Apr.
Deuce Programming (STAC)	Glasgow University	12 September	15 15 0	Full-time (12–21 September)	Repeated 10 January
Numerical Analysis for Automatic Computers	Brunel College	3 October	1 0 0	10 weekly lectures	7.00–8 30. p.m.
Digital Computer Appreciation Course	City of London College	18 January		10 weekly lectures	5.30–7.00 p.m.
Computers—Commercial Applications I	Ealing Technical College	29 September		10 weekly lectures	9.15 a.m.–12.15 p.m.
Computers—Commercial Applications II	Ealing Technical College	28 September		10 weekly lectures	2.00–5.00 p.m.
Programming of Digital Computers	Lanchester College	28 September	1 2 0	12 weekly lectures	6.30–8.30 p.m.
Simple Code for STANTEC–ZEBRA	Leicester College	13 September	1 10 0	10 weekly lectures	6.30–8.30 p.m.

Courses	*At*	*Commencing*	*Fee* £ s. d.	*Lectures or Sessions*	*Times*
EDP Systems	Manchester College of Commerce	12 October	2 10 0	15 weekly lectures	6.00–8.00 p.m.
Programming *IBM* 1401	Manchester College of Commerce	26 September	2 0 0	12 weekly lectures	
Programming Pegasus	Manchester College of Commerce	27 September	2 0 0	12 weekly lectures	
Programming *ICT* 1301	Manchester College of Commerce	29 September	2 0 0	12 weekly lectures	
EDP Applications	Manchester College of Commerce	13 January	5 0 0	10 weekly lectures	3.00–5.00 p.m.
Algorithmic Languages for Commercial & Scientific Work	Northampton C.A.T., London	26 September		13 weekly lectures	6.30–8.00 p.m.
Logical Design	Northampton C.A.T., London	27 September		10 weekly lectures	6.30–8.00 p.m.
Circuits of Digital Computers	Northampton C.A.T., London	17 January		10 weekly lectures	6.30–8.00 p.m.
IBM 1401 DP System	Northampton C.A.T., London	27 September		12 weekly lectures	6.30–8.00 p.m.
Facilities and Use of LEO	Northampton C.A.T., London	28 September		11 weekly lectures	6.30–8.00 p.m.
Computing for Civil Engineers I	Northampton C.A.T., London	29 September		24 weekly lectures	3.30–7.00 p.m.
Computing for Civil Engineers II	Northampton C.A.T., London	28 September		24 weekly lectures	3.30–7.00 p.m.
Introduction to Digital Computers	Northampton C.A.T., London	29 September		12 weekly lectures	6.30–8.00 p.m.
Simulation on Electronic Analogue Computers	Northampton C.A.T., London	19 September		13 weekly lectures	6.30–8.00 p.m.
Introductory Analogue Techniques	Rutherford College	29 September	1 15 0	10 weekly lectures	7.00–9.00 p.m.
Advanced Analogue Techniques	Rutherford College	12 January	1 15 0	10 weekly lectures	7.00–9.00 p.m.
Analogue Computers	The Polytechnic	29 September	1 1 0	12 weekly lectures	6.30–8.00 p.m.
Digital Computers	The Polytechnic	27 September	1 1 0	12 weekly lectures	7.00–8.30 p.m.
Electronic Computing Systems I	Sir John Cass College	26 October	1 0 0	6 weekly pairs of lectures	6.15–7.15 p.m. 7.30–8.30 p.m.
Electronic Computing Systems II	Sir John Cass College	18 January	1 0 0	6 weekly pairs of lectures	6.15–7.15 p.m. 7.30–8.30 a.m.
Computer Studies	Slough College	16 February		3 days (16 & 23 Feb., 2 March)	
Pulse Circuit Design	Twickenham Technical College	6 October		23 weekly lectures	7.00 p.m.

1960/61 LONDON MEETINGS PROGRAMME

1960	*Time*	*Title*	*Speaker*
Thursday, 22 September	Session I —10.00 a.m. to 12.00 p.m. Session II— 1.30 p.m. to 3.30 p.m.	Discussion Meeting on New Computers	Mr. G. H. Hinds (*BTC*) Dr. A. D. Booth (*Birkbeck College*) Manufacturers' Representatives
Thursday, 29 September	6.00 p.m.	ANNUAL GENERAL MEETING	
	6.30 p.m.	A Survey of Modern Programming Techniques	Mr. R. Bemer (*IBM* New York)
Thursday, 20 October	6.15 p.m.	The Experience of Applying a Commercial Computer in a British Organisation	Mr. A. J. Platt (*Pilkington Bros.*)
3–4 November		Discussion Meeting on Training of Computer Personnel	Details of this Meeting will be announced later
Tuesday, 29 November	2.30 p.m.	Techniques for Producing School Time-Tables on a Computer and their Application to Other Scheduling Problems	D. V. Blake and J. S. Appleby (*NPL*)

All meetings will be held at Northampton College of Advanced Technology, St. John Street, London, E.C.1

UNESCO FELLOWSHIPS IN INFORMATION PROCESSING AND ELECTRONIC COMPUTING

UNESCO has established under the 1959–60 Regular Programme six fellowships which are planned to enable highly qualified specialists to undertake research study abroad for a period of six months in one of the following fields:

1. Use of electronic computers for mechanical translation.
2. Theory of switching.
3. Use of computers for the reduction of geophysical data.

The National Commission has indicated to UNESCO that it wishes to present candidates for these fellowships.

A copy of the prospectus is attached for the information of the Panel. Interested candidates are being asked to forward dossiers, in accordance with the requirements set out in the prospectus, to reach the *United Kingdom National Commission for UNESCO*, Ministry of Education, Curzon Street, London, W.1, not later than the 20 September, 1960.

The conditions for the three fields are set out below.

1. *Mechanical Translation*

Qualifications of Candidates

A. Candidates should be research workers who have already conducted or are in the process of conducting an experiment in mechanical translation and who wish to compare their methods with those of specialists engaged in the same work in other countries.

or

B. Candidates should be research workers who have planned an experiment in mechanical translation and who need, in order to initiate the experiment, advice and mechanical facilities that can be found only in other countries.

or

C. Candidates should be research workers who wish to specialise in mechanical translation and who in order to do so need substantial training that cannot be provided in their home country in one of the disciplines relevant to mechanical translation.

Method of Selection

Candidates' dossiers must be submitted in five copies and must be accompanied by:

(*a*) A detailed description of the experiment in question, or, a clear indication of the type of training required (category *C*).

(*b*) A study plan indicating the institution or institutions where the candidate believes he can carry out his studies.

(*c*) Three letters of reference in support of application, and

(*d*) List of publications and scientific works, if any.

The dossier will be sent to the institution(s) in question with the purpose of ascertaining whether suitable study facilities can be offered.

Final selections will be made by the Director-General of UNESCO among those candidates for whom study facilities are assured.

Duration of Fellowships

To be determined.

2. *Theory of Switching*

Qualifications of Candidates

A. Candidates should be students or research workers who wish to specialise in the theory of switching and who in order to do so need substantial training in that subject that cannot be provided in their home country. They should be sufficiently competent in relevant disciplines, such as modern algebra, mathematical logic, graph theory, combinatorial analysis, and information theory, to be able to undertake directly the study of the theory of switching.

or

B. Candidates should be scholars or research workers who have already investigated or are currently investigating the theory of switching and who wish to compare their investigations with those of specialists engaged in similar work in other countries.

Duration of Fellowships

To be determined.

3. *Reduction of Geophysical Data*

Qualifications of Candidates

Candidates must have a doctorate in physics, geophysics or astrophysics, with a good mathematical background.

Study Programme

There exists a vast mass of observational data and records relating to geophysical phenomena, which await reduction and analysis. The successful candidates will be expected to study the possible application to this problem of modern automatic computing methods.

The study programme may include:

(*a*) a period of study and selection of a problem in a World Data Centre or an Astronomical and Geophysical Permanent Service;

(*b*) a period of study of automatic computing machines in an appropriate laboratory or computing centre;

(*c*) the preparation and execution of a computing programme for the analysis of the selected problem.

Method of Selection

As usual, selection will be made on the basis of candidates' scientific background and experience. Should several candidates have equally good qualifications, however, UNESCO will give priority to those whose field of interest is most closely related to the organisation's current programme.

ANNUAL PRIZES

At the Annual General Meeting of the *BCS* in September 1959 it was announced that two annual prizes would be offered for the best two papers in *The Computer Journal* or *The Computer Bulletin*. One of the prizes would be for a paper on business applications and the other prize would be for a paper on a mathematical, scientific or engineering application, or on logical design. Each prize was to be 20 guineas.

A sub-committee of the Editorial Board was set up to cover all these papers published between April 1959 and April 1960 inclusive. The decision of the Editorial Board will be announced at the 1960 Annual General Meeting on 29 September.

The system of marking of papers has been to award up to 20 marks under five headings:

(*a*) Importance of subject.
(*b*) Originality of work or approach.
(*c*) Critical appreciation of related work.
(*d*) Clarity of exposition.
(*e*) General quality of Summary, Introduction and Conclusion.

A total of 47 papers have been considered for the prizes, and it is hoped that this scheme will encourage the submission of more papers in the future for both *The Computer Journal* and *The Computer Bulletin*. Papers for consideration for the 1961 prizes must reach the Editors by 15 January 1961.

R. M. Paine

BRITISH COMPUTER SOCIETY LIBRARY

The nucleus of the library, which has as yet only completed its first year, is housed in the library of the Leicester College of Technology, whose librarian is the Society's honorary librarian. Its resources are as yet very limited, but the expenditure of the library grant during the coming year will considerably improve results from the services now offered.

These services are fourfold—the loan of books or other library material, the supply of photocopies, furnishing bibliographical, scientific or technical information with, if desirable, the assistance of a panel of experts, and assistance regarding selection and sources of films, filmstrips, etc. Photographic copies or any spare copies of available reprints may be borrowed at cost of postage. Copies for retention can be supplied at a price per page covering reproductional costs plus postage.

Ten loans have been made and five enquirers given helpful information.

So far the library has acquired 10 books, about 100 reprints, data sheets and the like, and regularly receives 20 periodicals, besides having incomplete files of 10 other periodicals.

Those currently received are:

Aslib Proceedings.
Association for Computing Machinery Journal.
Automatic Data Processing.
Automatic Programming Information.
British Conference on Automation and Computation Bulletin.
British Institution of Radio Engineers Journal.
Chartered Mechanical Engineers.
Computer News.
Data Processing.
Data Processing Digest.
Datamation.
ICT (*International Computers and Tabulators Ltd.*).
Institute of Petroleum. Journal.
Institute of Petroleum. Review.
Institution of Electrical Engineers. Proceedings, B.
Journal of Machine Accounting.
Management Science.
Mathematical Reviews.
South African Computer Bulletin.

Some copies are held of the following periodicals, besides others of less specific interest.

Automation Progress.
Chiffres.
Computers and Automation.
Datamatron.
Electronic Forum for Industry Bulletin.
Electronische Rechenanlagen.
Faculty of Actuaries Transactions.
Management Views.
Production Equipment Digest.
Provisional International Computation Centre Bulletin.

The work has been greatly assisted by those who have made regular gifts to the library and the thanks of the Society is accorded them.

DISCUSSION GROUPS 1959/60

Despite a late start this year, a considerable amount of success surrounded the Business Discussion Groups. About 250 members joined eight groups, some meeting fortnightly in order to cover their programme. Group No. 4 which is examining existing installations found it necessary to plan well into next year and has an extensive programme.

Group No. 6, the members of which are interested in Production Scheduling and Control, hope to present progress reports in September showing solutions of some of the general problems met in this field, and material is available for about a dozen meetings next session.

It is unfortunate that the Scientific subjects did not appear to appeal to many members. The "Coding of Data" group was sadly lacking in numbers and eventually closed down. The discussions on Statistics were more successful, but these were the only groups started this year. Response to a recent request for a Numerical Analysis group was good and this may be the forerunner of others being started by request.

Any member who wishes to suggest the formation of further Discussion Groups should write to P. V. Ellis, Chairman of the Study Group Committee. Other cognate suggestions in which members feel there may be general interest will also be welcomed.

THE BRITISH COMPUTER SOCIETY LIMITED

INCOME AND EXPENDITURE ACCOUNT

For the year ended 30 April 1960

1959 £	£		£	1960 £	£
		INCOME			
		Membership Income			
6,298		Annual Subscriptions			7,153
613		Entrance Fees			317
		The Computer Journal			
		Sales	1,735		
		Advertising	1,602		
				3,337	
		Less Costs		3,330	
114					7
		The Computer Bulletin			
		Sales	171		
		Advertising	770		
				941	
		Less Costs		1,556	
(718)					(615)
		The 1959 Conference			
—		Income		2,233	
—		Expenditure		1,799	
					434
24		*Deposit Interest*			—
6,331					7,296
		EXPENDITURE			
	2,223	Salaries and National Insurance		1,820	
	550	Office Rent and Rates		513	
	1,561	Stationery, Postage and Telephone		749	
	217	General Expenses		90	
	146	Depreciation of Office Equipment		130	
	28	Loss on Sale of Office Equipment		42	
	81	Legal Charges		—	
	32	Audit Fee		32	
	322	Public Relations		114	
	216	Council and Committee Expenses		267	
	32	B.C.A.C. Subscription		21	
	—	I.F.I.P.S. Subscriptions		90	
	83	Provision for Bad and Doubtful Debts		13	
	141	National Meetings		78	
	528	Branch Advances and Expenses		435	
6,160					4,394
171		EXCESS OF INCOME OVER EXPENDITURE			2,902
150		*Add* Accumulated Fund at 1 May 1959			291
—		EEA/OABETA Grant			500
321					3,693
30		*Less* Under-provision for Taxation in Previous Year			2
£291		ACCUMULATED FUND AT 30 APRIL 1960			£3,691

THE BRITISH COMPUTER SOCIETY LIMITED

BALANCE SHEET
as at 30 April 1960

1959 £	£		Cost £	Accumulated Depreciation £	£
		FIXED ASSETS			
532		Office Equipment	785	267	518
		CURRENT ASSETS			
185		Stock of Publications		100	
1,106		Debtors and Prepayments		1,137	
329		Bank and Cash Balances		4,384	
					5,621
2,152		TOTAL ASSETS			6,139
		Less CURRENT LIABILITIES			
	362	Creditors and Accrued Charges		1,056	
	1,499	Amounts Received in Advance		1,392	
1,861					2,448
£291		NET ASSETS REPRESENTED BY THE ACCUMULATED FUND			£3,691

LIABILITY OF MEMBERS

Note: The Society has no share capital, but in terms of clause 6 of the Memorandum of Association every member undertakes to contribute a sum not exceeding £1 in the event of the Society being wound up, during the time that he is a member, or within one year after he ceases to be a member.

On behalf of the Council,

F. YATES, *Chairman.*
J. HOUGH, *Treasurer.*

REPORT OF THE AUDITOR TO THE MEMBERS OF THE BRITISH COMPUTER SOCIETY LIMITED

I have audited the books and accounts of The British Computer Society Limited for the year ended 30 April 1960 and have obtained all the information and explanations that I considered necessary. Proper books of account have been kept and the foregoing Balance Sheet is in agreement therewith.

The said Balance Sheet and the annexed Income and Expenditure Account give the information required by the Companies Act, 1948, and give, in my opinion, a true and fair view of the state of the Company's affairs as at 30 April 1960 and of the excess of income over expenditure for the year ended on that date.

LONDON
24*th August* 1960

E. F. MILNE

Chartered Accountant.

CORRESPONDENCE

Letters from readers are welcomed, and should be addressed to The Editors, The Computer Bulletin, Finsbury Court, Finsbury Pavement, London, E.C.2. The name and address of the writer must be given, but will not be published if requested.

Square Root Extraction

Sir,

Square root extraction of a number N is generally performed on computers by the Newton–Raphson method:

$$x_{i+1} = \tfrac{1}{2}(N/x_i + x_i)$$

Depending on the instructions available, it may be more efficient to rewrite the formula as:

$$x_{i+1} = \tfrac{1}{2}(N + x_i^2)/x_i$$

Stored program computer programmers are aware of this, but it is less known by users of electronic calculating punches. As an example, I have prepared two subroutines for the *IBM* 604.

The common program requires 32 steps for 4 iterations. By application of the above-mentioned trick, however, two steps are saved per iteration. Without loss of accuracy, the program is shortened to 24 steps.

Calculating punches are controlled by panels. As their capacity is relatively small, the saving of, for example, 8 program steps is especially useful when the square root extraction has to be combined with other calculations.

Gevaert Photo-Producten N.V., Yours, etc.,
Septestraat, Mortsel (Belgium). J. L. F. DE KERF

Note: Readers may obtain copies of the mentioned routines from the offices of the Society.

Electronic Brain?

Sir,

Can a machine think? It seems to me that all one's thought processes must be based on the contents of one's brain, and that therefore from a fundamental theoretical point of view, it is not impossible to conceive a machine endowed with all the properties of the brain, and carrying the same quanta of information, criteria, comparison techniques, and so on, which could then carry out the processes called "thought," which are usually carried out by the brain.

In fact, it is possible to conceive that such a device, given the endowment of a number of individual brains, could carry out "thought" processes more reliably than any individual human brain.

A comprehensive device of this character would have to be endowed with the knowledge and experience of every facet of human endeavour—a tall order indeed; but is it not possible that, as the years go by, as new tools are discovered, and as libraries and routines relating to specialities are gradually built up and integrated, bit by bit, such a result could be eventually attained.

What we are seeing today is the mechanisation of micro-portions of the operational scope of the human brain, but as each such portion is conquered in turn, as from a study of the specialist mechanisms, more generalised criteria are evolved and in turn integrated stage by stage. Who would prophecy a limit to the ultimate goal?

9 Drapers Gardens, Yours, etc.,
London, E.C.2. U. JOHN PRIOR

Automatic Coding Languages

Sir,

With the advent of automatic coding languages some four or five years ago, various names have been chosen for particular languages. It is a surprising factor that a large number of the names which have been constructed (i.e. those not already existing in the English language) are mere duplications of names used for other purposes. Four cases come to mind, firstly the *IBM* Commercial Translator was originally intended to be called Comtran, but this name was found to apply to a Commercial Transport Company in the United States. Similarly, the name applied by *CDL* to their automatic coding system, Codel, was found to have been previously used on the Continent to describe a Visible Planning Board System. Both the names Comtran and Codel have been dropped as names for automatic coding systems. Recently it has come to light that one of the early systems, Flowmatic, developed by *Remington Rand*, duplicates a name which was previously applied to an automatic dispenser for water and bird seed in a bird cage.

International efforts are not without their difficulties in this field. The Algorithmic language, developed originally in Europe and recently widened in its scope, has been given the name Algol. It may not be known that this name is also used for the largest of the Solid Fuel Rockets (a modified Polaris) which have been launched in the American satellite programme. It may be of significance that a recent attempt failed to launch the rocket successfully.

Yours, etc.,
Computer Developments Ltd. J. H. WENSLEY

Common Languages

Sir,

I was extremely pleased to read the article relating to the change in aims of the *BCS* Committee on Autocoding for business problems.

This, however, I find rather surprising, especially in view of Mr. R. M. Paine's reply to my previous letter in which I advocated that the Committee would do better to study existing systems, rather than introduce a new range.

52 *Shirley Drive,* Yours, etc.,
Hove, Sussex. JOHN W. MITCHELL

BOOK REVIEWS

Electronic Computers: Principles and Applications

By T. E. Ivall, 2nd Edition 1960; 263 pages. (London: *Iliffe and Sons Ltd.*, 25s. 0d.)

This new edition has been almost entirely re-written. The author claims that the book is an introduction for those who are beginning to take an interest in computers. Its scope covers both digital and analogue type of equipment. The style is very straightforward and considerable care has been taken to avoid complex mathematical illustrations.

It is suggested by the publishers that the reader needs some knowledge of electronics or electrical engineering to understand most of the book. This may help, but any layman sufficiently interested in electronic computers to read this book will find, with the exception of two chapters on analogue computers, that the explanations and clear diagrams can be easily understood.

Only two chapters are assigned to "applications" and in both of them, one on analogue and one on digital computers, no attempt is made to give full details of any system. Most of the book deals with principles and simple circuitry. The sections dealing with storage systems and programming are well written. Considerable care and study have been given to the collection of information on "Recent Developments."

The use of computer "jargon" has been avoided wherever possible and simple explanations are given when the introduction of a new term cannot be avoided.

The author claims that this is not a textbook, but the simple and clear style of the explanations make it an excellent background book for laymen who plan to attend introductory computer courses in the coming winter.

L. R. Crawley

Numerical Methods for High Speed Computers

By G. N. Lance, 1960; 166 pages. (London: *Iliffe and Sons Ltd.*, 42s. 0d.)

With the advent of automatic electronic computers a great deal of research has been done in the field of numerical analysis to develop new techniques particularly suited to exploit these new tools. Hitherto much of this work has only been published in original papers and Dr. Lance has now collected many of these methods into a single volume.

The book begins with an introduction to high-speed computers with discussions on such questions as scaling and overflow, the limitations on the size of store, computer faults and programmers' errors. Chebyshev Polynomials are then considered and used for the evaluation of some of the elementary functions such as the exponential logarithmic and trigonometric functions and the inverse sine, cosine and tangent functions. Methods for computing square roots, complete Elliptic Integrals, Jacobian Elliptic Integrals and Bessel Functions are also given.

The Runge-Kutta method is applied to systems of ordinary differential equations in Chapter 3 and two methods are given for the case of the second order differential equations in which the first derivative is absent.

Matrix methods are discussed in Chapter 4. The method for extracting the roots and vectors of a matrix by iteration is given and other methods for the particular case of Symmetric Matrices are considered. Matrix Interpretive Schemes and the problems arising with matrix inversion are also included.

In the chapter on the Numerical Solutions of Partial Differential Equations iterative and matrix inversion methods are given for solving equations of the elliptic type, the method of characteristics is applied to equations of the hyperbolic type and three methods are given for equations of the parabolic type.

The last chapter is devoted to miscellaneous processes and includes such things as methods for solution of polynomial equations, evaluation of continued fractions, interpolation, and the numerical evaluation of definite integrals and inverse Laplace Transforms.

The book ends with a small appendix devoted to a description of floating-point arithmetic and an extensive and up-to-date bibliography.

The author has always taken a practical approach to the subject and he has given due consideration to such topics as the time taken to obtain a result and the accuracy of the result so obtained. The book should prove invaluable to any scientist interested in the application of electronic computers to the solution of his own particular problem.

P. M. Hunt

Industrial Electronics and Control

By R. G. Kloeffler, 1960 (2nd edition); 540 pages. (New York: *John Wiley and Sons Inc.*, London: *Chapman and Hall Ltd.*)

The claim made for this book is that it "differs from its predecessors and from all previous texts in that it approaches the electronic theory of rectification, amplification and oscillation through solid state theory rather than by way of the vacuum and gaseous tubes." In support of this claim it may be said that the first seven chapters form a valuable descriptive account of the basis of electronic theory and the many devices derived therefrom, beginning with electrical conduction in solids followed by electron emission and gaseous conduction. The value of these chapters in giving an overall view of modern ideas is undoubtedly high. The brevity of the treatment, however, leads to notable omissions. For example, after describing the Hall effect the author states that it has been "employed to prove the presence of holes in p-type semiconductors" without any subsequent mention of the numerous industrial applications of the Hall effect which have been developed in the last decade.

Chapters 8 to 18 are concerned with the applications of semiconductor devices, vacuum tubes and gaseous electron tubes. The applications discussed include servomechanisms, computers, welding, h.f. heating, X-rays, measuring instruments, electrostatic precipitators, etc. Again the work is largely descriptive and its brevity can be indicated by mentioning that the principles of control and servomechanisms occupy thirteen pages and analogue and digital computer principles take up twenty-six pages. There are indications that the author is not always familiar with up-to-date practice in all fields. Thus in discussing analogue computers there is no mention of automatic drift correction which has been universally practised for several years in general purpose

installations and it is stated that "checking and resetting for drift are usually necessary at 30-minute intervals."

The book will probably be most useful to students who are beginning studies in electrical engineering and for undergraduates in related disciplines who wish to have a general view of developments in electronics. Another class of "student" who may well find interest in its pages is the specialist electrical or electronics engineer whose college days are far behind and who wishes to know how electronics are currently applied in fields remote from his own speciality.

The book is very well illustrated and contains many photographs of devices. Examples are given at the end of each chapter together with a good selection of references for more detailed study. There is no doubt that by working through the examples and following up by deeper reading from the references provided the serious student could acquire a sound knowledge of the topics discussed.

P. H. HAMMOND

Analogue and Digital Computers

Edited by Say, Haley and Scott, 1960; 308 pages. (London: *George Newnes Ltd.*, 50s. 0d.)

Training methods vary in the computer industry, but there must be many laboratories where the procedure invariably adopted with a newcomer is first of all to sit him down in a quiet corner and give him something to read. This book is an unpretentious and welcome addition to the rather limited list of those which can be usefully pressed into his hand on such occasions.

The first 30 pages are devoted to an introductory chapter which outlines the basic ideas of both analogue and digital computers; thereafter a section of some 100 pages deals exclusively with various aspects of analogue machines, while a further section of about 170 pages deals similarly with digital machines. Most chapters are followed by useful bibliographies in which the editors have wisely resisted the temptation to confuse by being unnecessarily comprehensive; however, some of the references are, perhaps inevitably, rather out of date.

The technical essentials of both branches of electronic computing are covered by a panel of specialist authors in sufficient detail to be genuinely informative, but, on the whole, without unnecessary elaboration. The pace of technical development probably accounts for the scant attention given to semiconductor, as opposed to thermionic, devices and circuits; no doubt this was appropriate when the text was written. In any case, the majority of practical transistor circuits are derived fairly directly from those hard valve circuits which are discussed. The account of cathode-ray tube storage could have been briefer considering that, although the book does not say so, it is an obsolete technique; the restricted Nyquist stability criterion should perhaps have been introduced with the specific reservation that it applies only to single loop feed-back systems; digital representation of negative numbers is treated rather untidily and without mentioning that the "ones complements" convention inconveniently admits two forms of zero; joints and cross-overs are rather ambiguously drawn in one or two circuit diagrams. Such defects as these may irritate those who are already knowledgeable, but they will not seriously mislead the newcomer.

As might be expected, and indeed as the editors admit, the main shortcomings of the book are of form rather than content; the text lacks continuity and there is a good deal of repetition. Continuity is particularly a problem in the section on analogue machines, since, unlike those of digital computers, their principles do not allow convenient distinctions to be made between applications, system design, and engineering techniques, for the purpose of exposition. This is perhaps borne out by the fact that this section is divided into only three chapters, whereas that on digital machines splits without undue strain into six. A table of contents giving rather more indication of the coverage of each chapter would have made the analogue section easier to refer to.

Much of the repetition encountered, on the other hand, appears to be the result of an excess of "introductory" material. Each of the two main sections has its own introductory chapter, which, in one or two cases, notably in explanation of digital programming, repeats material which is not only already in the first introductory chapter of the book but also in more specialised chapters as well. It is difficult to agree with the editors that this is justified by the different approaches on each occasion; moreover, one feels that the space occupied by such redundant material could have been devoted more usefully to other things. There is, for instance, virtually no mention of techniques for conversion between analogue and digital representation. Perhaps more important, there is no attempt to outline briefly, with illustrations, one or two typical complete installations; if it had been properly done, this would have greatly improved the coherence of the book as a whole.

To introduce all the important technical details of both analogue and digital machines in a single volume of some 300 pages must have been difficult; to attempt to do this by dovetailing the contributions of a number of independent specialist authors must have been supremely difficult. Despite its inevitable shortcomings, this book does succeed, more economically and less pretentiously than most of its predecessors, in giving the newcomer with a grounding in electronics an idea of what electronic computing is all about.

J. S. MACMULLAN

Analogue—Digital System

Redifon Ltd. demonstrated their new RADIC system (Redifon Analogue Digital Computing System) early in July. This is basically an analogue computer which incorporates analogue/digital and digital/analogue convertors, so that it can use digital units and digital input/output where this is more convenient or accurate. Analogue units include amplifiers, summing units, integrators, servo-multipliers and a variety of non-linear units interconnected by a patch panel. Analogue output is by a cathode-ray tube or a twin plotter.

An interesting feature is the digital memory unit consisting of two tape decks using sprocket-driven magnetic tape. Information is encoded in parallel and the tape is moved by single pulses to the sprocket drive—the tape being stationary between pulses. A closed loop of tape with variable delay between reading and writing heads is used as a transportation (or distance-velocity) lag or for correlation analysis. The decks can be fitted with tape spools and used as digital stores.

Digital input is by a keyboard and output by a digital voltmeter and printer. On large installations coefficients can be set by the keyboard and servos, and the values set are then printed out providing a valuable record of the set-up.

BRANCH PROGRAMMES 1960/61

The following information was received by the honorary editors up to the time of going to press: programmes are subject to alteration. Members wishing to bring guests are requested to apply to the local honorary secretary for invitation.

BELFAST

1960

Thur. 13 Oct.	Film Evening.
Thur. 10 Nov.	Production Control. B. Hart (*ICT*).
Thur. 8 Dec.	Computer Language. R. A. Brooker (Manchester University).
1961	
Thur. 12 Jan.	Visit to *ICT* Factories at Belfast.
Thur. 9 Feb.	Advanced Techniques in Storage.
Thur. 9 Mar.	Superannuation.
Thur. 13 Apr.	Annual General Meeting and a talk to be arranged.

BRISTOL

1960

Wed. 28 Sept.	Computers for Beginners. Lecturer to be arranged.
Wed. 26 Oct.	Numerical Analogue Control of Machine Tools. O. S. Puckle, M.B.E. (*EMI Electronics Limited*).
Thur. 24 Nov.	Half-way House. A. J. Barnard, City Treasurer, Norwich Corporation.
1961	
Tues. 17 Jan.	To be arranged.
Tues. 14 Feb.	To be arranged.

Meetings will be held in the small lecture theatre, Queen's Building, Engineering Department, The University of Bristol, commencing at 7.15 p.m.

NEWCASTLE

1960

Tues. 4 Oct.	A computer or a Data Production Line. D. W. Hooper (*National Coal Board*).
Tues. 1 Nov.	A Computer Application. R. G. Jecks (*Legal and General Assurance Society*.)
Tues. 6 Dec.	Sorting Techniques and a Special Application. D. W. Davies (*Autonomics Division, NPL, Teddington*.)
1961	
Wed. 11 Jan.	Staff and Organisation of a Computer Department. K. L. Scott (*Rowntrees Limited*).
Tues. 7 Feb.	Planning and Installing a Computer. E. Kay (*Standard Telephones & Cables Limited*.)
Tues. 7 Mar.	Use of a Computer for Production Control.
Tues. 11 Apr.	To be arranged later.

All lectures except the first will be held at the University Computing Laboratory, 1 Kensington Terrace, Newcastle upon Tyne 2, commencing at 7.00 p.m.

BIRMINGHAM

1960

Wed. 19 Oct.	Report on visit to USA. J. G. Grover (*Courtaulds Limited*).
Wed. 9 Nov.	Developments with Magnetic Tape. G. B. Griffiths (*Babcock and Wilcox Limited*).

Times and places of meetings may be ascertained from honorary branch secretary.

LEICESTER

1960

Thur. 20 Oct.	Theory *v*. Practice. D. S. Greensmith (*Boots Pure Drug Company Ltd.*).
Thur. 17 Nov.	Planning the Introduction of a Computer for Stores Inventory Work in the RAOC. Lt.-Col. J. J. Wise, O.B.E., and Mr. Thurston. (Central Ordnance Depot, Chilwell.)
Thur. 15 Dec.	A Film Evening.
1961	
Thur. 19 Jan.	The Ferranti Atlas Computer. Dr. S. Gill (*Ferranti Limited*.)
Thur. 16 Feb.	The use of Computers in the Boot and Shoe Trade. A. R. P. Fairlie (*Remington Rand Ltd.*)
Thur. 16 Mar.	To be arranged.

Meetings arranged will be held at the Leicester College of Technology at 7.00 p.m.

MANCHESTER

1960

Wed. 5 Oct.	Annual General Meeting and a demonstration of the University Computer to be held in the Manchester University Computer Laboratory at 7.00 p.m. All the following Meetings will be held in the Manchester College of Science and Technology.
November	To be arranged.
December	To be arranged.
1961	
January	Reliability of Computers.
February	Atlas and its Design. Prof. T. Kilburn.
March	Application of Computers to Purchasing and Inventory Control at the Royal Ordnance Depot, Chilwell. Lt.-Col. J. J. Wise, O.B.E.
April	A Mathematical Topic.

MIDDLESBROUGH

1960

Tues. 27 Sept.	Visit to Computing Centre, *ICI* Wilton.
Tues. 11 Oct.	Discussion on 2nd Computer Conference.
Tues. 1 Nov.	An Accounting Application. P. J. Lown (*Reckitt & Sons Ltd.*).
Thur. 1 Dec.	Title to be announced. K. D. Tocher (*United Steel Company Ltd.*).

It is hoped to arrange further meetings in January, February, March and April.

GLASGOW

1960

Mon. 17 Oct.	Planning for a Computer. K. D. Henderson (*J. & P. Coats Limited*).
Mon. 14 Nov.	Electronic Calculators in Commerce (1). W. A. Donaldson (*Rolls Royce Limited*).
Mon. 12 Dec.	Electronic Calculators in Commerce (2). Some Users' Experience. *Speakers—* G. B. Esslemont, City Chamberlain, Glasgow Corporation. J. C. Mair, Western Regional Hospital Board. E. Maxwell, South of Scotland Electricity Board. T. B. Simpson (*John Brown & Co.* [*Clydebank*] *Limited.*)

1961

Mon. 30 Jan.	Computers in *ICI*. G. E. Thomas (*ICI*).
Mon. 27 Feb.	EMI Computers in Commerce. By Speaker from *EMI* (*Electronics*) *Limited.*
Mon. 20 Mar.	The Development of a Computer. Speaker to be announced.

HULL

1960

Wed. 5 Oct.	The new Manchester University "MUSE"—Prototype for the new "Atlas" Computer. Prof. T. Kilburn, Computing Machine Laboratory, Manchester University.
Wed. 2 Nov.	Actuarial Work and Computers. To be arranged by *Messrs. Duncan C. Fraser & Company.*
Wed. 7 Dec.	Some Aeronautical Applications of Computers. S. H. Hollingdale, Royal Aircraft Establishment. (*Note:* The above meeting will be held jointly with the Brough Branch of the Royal Aeronautical Society and will commence at 7.30 p.m.)

1961

Wed. 11 Jan.	On Line Process Control. A. D. Jeffery, *Panellit Limited*, Elliott-Automation Group.
Wed. 8 Feb.	Learning and Machines. Dr. W. Taylor, Communications Research Centre, London University.
Wed. 8 Mar.	General Use of Computers in Railway Research Work. P. J. Coates, The British Transport Commission.
Wed. 12 Apr.	Avoiding Mistakes by Oversight in an Industrial Program. A. Young, Computer Laboratory, Liverpool University.

Meetings are held at Royal Station Hotel, Hull.

LIVERPOOL (Liverpool, Merseyside & District Branch)

1960

Tues. 20 Sept.	Electronic Computing in 1960. Prof. L. Rosenhead, C.B.E., F.R.S.
Thur. 27 Oct.	The *ICT* Range of Computers. E. Martin Webb (*International Computers & Tabulators Ltd.*)
Mon. 21 Nov.	Some Applications of Computers in Aircraft Design. J. H. McDonnell (*English Electric Aviation Limited.*)

1961

Wed. 25 Jan.	Planning the Introduction of a Computer for Stores Inventory Work in the RAOC. Lt.-Col. J. J. Wise, O.B.E. (Central Ordnance Depot, Chilwell.)
Wed. 22 Feb.	Applications of Computers to Smaller Concerns. O. W. Standingford (*Herbert Wolf Limited.*)
Tues. 21 Mar.	Computers and Banking. R. Hindle (*Martins Bank Limited.*)

Journées D'Étude 1960 des Moyens Automatiques de Gestion

A conference, under the above title and organised jointly by *L'Association Française de Calcul*, *La Société Française de Recherche Opérationelle* and the French section of the *Institute of Management Sciences*, will be held from 19 to 22 October 1960 at L'Hôtel de la Société des Ingénieurs Civils de France, 19 rue Blanche, Paris 9ème. The conference is open to all interested persons.

The provisional programme, dated 15 June 1960, issued by the Secrétariat des Journées d'Étude 1960, 170 Avenue Paul-Doumer, RUEIL-MALMAISON, Seine-et-Oise, gave details of the seven sessions. Titles are:

19 *October*. Use and application of electronic ensembles (4 papers). Descriptions of current applications (6 case studies, 2 IBM, 2 Bull, 1 SEA, 1 CGO).

20 *October*. The simulation of management problems (4 papers). Experimental methods in business and economics (4 papers).

21 *October*. Economic aspects of the use of electronic ensembles (3 papers). Introduction of an electronic ensemble into a business (6 papers).

22 *October*. Repercussions (*incidences*) of administrative automation (3 papers).

Further particulars, including titles of papers and application form, may be obtained from the Secretariat at the second address given above. Fees, which do not include accommodation, but include a report of the proceedings when published, will be NF 225 with banquet, NF 195 without banquet; wife or member of family accompanying participants, for whom special activities are being arranged, NF 20.

FOR WHAT IT'S WORTH

by G. J. Gee

At present there are three principal devices by means of which the computer under discussion can communicate its results to the outside world. By far the most commonly used is the card punch, whose advantages and disadvantages are well known to all users. The pictorial display on the oscilloscope, though potentially very versatile, in practice proves to be somewhat inflexible, and requires much storage space. Further, the pattern of 32 × 32 dots is of inherently low resolution, and above all, the record is not permanent. A built-in camera could overcome this objection, but the others would still remain, and there would be added the delay and inconvenience of developing the film. The automatic plotter produces, of course, a vividly graphic display. It does, however, work rather slowly, and is very expensive.

It is therefore suggested that the output facilities be supplemented by the addition of a knitting machine. Such a device would have many advantages, including the following:

(*a*) *Inexpensiveness*

A wide range of domestic models are available at prices ranging from £15 to £106 10s. 0d. The more expensive versions incorporate facilities for knitting in several different colours simultaneously, and for producing buttonholes, loops, hems and various other special-purpose patterns.

(*b*) *Clarity*

When several different graphs are to be superimposed, the output may be knitted by Fair Isle techniques, using a different colour for every curve.

(*c*) *Versatility*

It is safe to assert that no output medium currently used provides such a number of varieties of format as is possible with a knitting machine. If the results are required in alphabetic or numerical form, instead of being restricted to the set of alpha-numeric symbols, there is no limit to the variety of characters which may be employed. If the output is to be in graphical form, the curves may be produced together with their co-ordinate axes (whether Cartesian or curvilinear), labels and text. The format may be designed so as to be suitable for immediate publication by photographic techniques. If the output is to represent a surface in three dimensions, then two projections may be knitted superimposed on each other, one in red wool and the other in green, so that the fabric need merely be viewed through appropriately coloured spectacles to create a stereoscopic effect of seeing the surface in 3D. Alternatively, the surface may be knitted directly in three dimensions, which would be very convenient for turbine blade designing and similar investigations. Indeed, in such a case, the output could be knitted in the full scale of the blade in a fairly rigid thread (such as nylon, or cotton moistened with starch), which could be employed as the master mould or template from which to fabricate the blade. If the knitter were equipped with sock needles, it could be used to produce an output in the form of a long tube, e.g. if the computer were producing a continuous sequence of curves (such as a sequence of curves, converging to an eigenfunction), the curves in polar co-ordinates could be knitted as the successive sections of the tube, at intervals of one stitch along the tube.

(*d*) *Electromagnetic Output and Input*

Investigations are currently being made by several research workers of the practicability of constructing computer storage devices by knitting wires together (a simple Kt 1, P 1 stitch seems the most promising) and coating the resultant circuit with ferrite paste. This is designed to avoid the difficulty and expense of threading ferrite cores on matrices of wires. Should these experiments prove to be successful, such circuits would be eminently suitable as a form of output from the knitting machine fitted to the computer. By using fine wires of soft insulated copper, information could be built into circuits which could then be plugged into an immense variety of electrical devices, so as to control their behaviour. In particular, such circuits could be plugged into the computer, either at the input stage (as would be most suitable for data), or into the operating circuits, if it were desired to build in additional arithmetical or logical facilities, subroutines or programs. Furthermore, such circuits could well be hand-knitted, so that input data and programs could be prepared by the girls of the Hollerith Office by means of ordinary knitting needles, which would undoubtedly be less wearing on their delicate fingers than the present system of punches, and would not interrupt their conversation.

(*e*) *Compactness*

Most systems of storage (punched card, punched tape, magnetic tape or photographic film) require an area of several square millimetres to record a single binary bit of information. If the output circuit were knitted by a stocking machine on 66 gauge mesh using very fine wire (15 denier), it is estimated that four bits could be stored for every square millimetre of fabric. Moreover, precise positioning of the bits would not be so crucial as with the current systems of storage, and an experienced operator could read the circuit visually, which cannot be done with magnetic tape.

It is interesting to note the historical forerunners of the proposed output, in the form of the quipu of the Peruvian Amerindians (cf. Mason, pp. 73 *et al.*), and the similar device used in China during the early dynasties (cf. Needham, Vol. 1, pp. 229 and 237). In each case, intricately knotted cords were used to record information, and there is some evidence that calendrical computations were performed by their means. On the other hand, punched cards were first devised (in the late 18th century) specifically for the purpose of controlling the weaving of fabrics by the Jacquard loom.

The principal objection to a knitted form of output appears to be the risk of ladders in the fabric, but with adequate control of the knitting tension, this risk should be no more serious than the current risk of tearing cards. However, there remains the problem of modifying data or programs once they have been knitted. The author would welcome proposals for standard alphabets and lists of other characters to be built into the machine, for modifications to existing autocodes so as to adapt them to knit their outputs, and for a family of programs to convert existing programs to knitted circuits.

A program which could well be written to test the new output would be a demonstration program to knit socks for visitors, incorporating their own initials.

References

Mason, J. Alden. *The Ancient Civilizations of Peru.*
Needham, Joseph. *Science and Civilization in China.*

THE BISRA COMPUTER

Among a series of visits during the past few months, a small party of Society members was welcomed to the British Iron and Steel Research Association (BISRA) at Battersea on 30 June 1960 by Mr. R. J. Taylor, who gave a brief description of the work carried out by the Operational Research Department. The Department consists of three sections: the Human Factors Section, which is concerned with problems primarily concerned with the human element; the Computer Applications Section, which provides a computing service and advises the steel industry on the application of computers; and the Operational Investigations Section which undertakes those operational research studies not basically concerned with personnel or computers. The computer, a Ferranti PEGASUS Mark I, was installed in 1957 and has punched-tape input and output, with off-line teleprinters. The input and output facilities are adequate for general scientific work.

BISRA did not use their computer for payroll calculations at all, and the party had been misinformed about this. Nevertheless, Mr. F. J. J. Johnston gave an interesting talk on a feasibility study which had been conducted on a payroll problem for a member firm of the Association.

This included a very general summary of the final proposals for the payroll routine and emphasis was placed on those aspects of the study which would have an interest beyond the steel industry. The proposals were divided into three main sections: the calculation of wage rates, the analysis of time worked, and the calculation of gross and net pay. The first section was dealt with summarily since the wage rate structure in the steel industry is too complex to describe briefly. One interesting aspect was the use of formulae derived by means of curve-fitting techniques to calculate bonus rates instead of storing and using the existing detailed tables.

The second section, that of time analysis, was dealt with in greater detail because the principle involved in using the computer for this function could be applied to any works payroll in which clock cards are used for recording time worked. It was shown how the computer would form two lists for each employee, one showing the actual periods worked, the other showing those periods when the employee should have been present at the works. By comparing one with the other a complete time analysis would be made showing normal time worked, absence, overtime, lateness, etc. Finally, net pay would be obtained from gross wages by calculating income tax and national insurance contributions and deducting them together with the other deductions.

After a discussion, the following applications were demonstrated.

(1) *Montecode*

An example of the use of "Montecode" was run. Montecode is an interpretive program developed by BISRA which greatly eases the preparation of programs for the Monte Carlo simulation type of calculation. The actual simulation demonstrated was the scheduling for furnace repairs in a melting shop.

(2) *Multiple Regression*

The analysis of the factors influencing the roof life of an open-hearth furnace was illustrated. The computer was used to perform the statistical technique of multiple regression on the relevant data.

(3) *Data Processing*

A member firm used the computer for routine data processing work on a regular contract basis. The necessary programs had been prepared by BISRA.

(4) *Bar Cutting*

The end product of a certain steel rolling mill is a variable length of section up to perhaps 200 feet in length. The lengths required by a customer vary widely but average 35 feet. It was shown how a computer could be used to select from a list of customers' requirements in such a way to leave a minimum of waste. The final cutting instructions could be reached within 3–4 sec. (a speed often necessary in the steel industry) and the associated waste would be less than 1%. This easily represented a sufficient saving to justify the installation of an on-line computer, even if a second computer was necessary to cover maintenance and breakdown.

(5) *Payroll*

In order not to disappoint the party a demonstration monthly staff payroll, which BISRA had programmed several years ago, was demonstrated. This had most of the problems associated with payrolls; advantage was taken of the triple output punches to produce separate tapes for payslips, bank credit notes and an up-to-date statement tape, ready for the next run. The full calculations take about one second per employee.

NEW CREED EQUIPMENT ON SHOW

In the DATA PROCESSING section of the Creed stand at the London Business Efficiency Exhibition, 3–12 October 1960, is the *Creed Model* 2000 *Tape Store*. With punched paper tape as a data processing document, there is a growing need in commercial systems for quick access to selected information stored in paper-tape form. The Creed Tape Store has been developed to satisfy this requirement, and provides means for the storage of 120,000 characters, access to any of which can be obtained in an average time of only 18 seconds.

The store consists, essentially, of a metal cabinet housing two power-driven tape reels, one to wind and the other to unwind, together with a tape-reading mechanism. A 7-track tape is used in the store. Data are recorded in blocks on five of the tracks, the sixth track is used for an identifying code and the seventh for operating a photo-electric counting device.

When information is required from the store, the tape is automatically drawn at high-speed off one reel through the tape reading head to the approximate position of the desired block of data. On reaching this, the rapid feed action stops and the tape is then fed step-by-step until the exact point is located, when the information is read out.

At the exhibition, information in the store is selected by the operation of a simple keyboard and recorded externally both as punched tape and printed page copy at a speed of 10 characters per second.

Creeds also exhibit the prototype of their new model, the 1000 *Output Printer*.

Scheduled to go into production next year, the Model 1000 is a high-speed serial (character-by-character) printer designed to operate at 100 characters per second (1,000 words per minute)—*ten times* that of the fastest teleprinter. It will be

available either as a direct on-line computer output recording printer, or as an off-line play-back device operating under the control of punched paper tape. The latter method of operation is demonstrated at the exhibition.

In the Model 1000 the printed characters are not formed from solid type. Instead, an ingenious print head is used consisting of 25 styli or pins arranged in a compact 5×5 grid formation, approximately 0·1 in. high and 0·08 in. wide. Characters are formed by impinging the styli on the paper via a conventional ink ribbon, their combined operation building up each character in a pattern of dots, mosaic fashion. The styli are operated by hydraulic pressure impulses controlled by the external electrical signals received by the printer.

The print head traverses left to right, a character at a time, across the paper which is retained in a sprocket feed platen. The latter is readily adjustable to take paper from 8 in. to 16½ in. wide in continuous form, having cross-perforations at intervals for convenient separation into pages.

The printing line length is variable between 10 and 150 characters, as required, and up to four copies may be obtained using interleaved carbon paper.

The new *Creedomat Tape Punching/Reading Electric Typewriter* is also on show.

It consists of a special IBM Electric Typewriter and interconnected Creed Model 25 tape punch and Model 92 reader unit, which together provide for the simultaneous preparation of typed copy and 5-, 6- or 7-track punched paper tape, at speeds up to 100 words per minute. The play-back facility permits data recorded on punched tape to be automatically translated into typed page copy at 100 words per minute.

Provision is made for the by-product tape to be punched with all or only selected typed data; facilities are also available for tape to be corrected, revised and duplicated. If required, the typewriter may be used by itself for normal correspondence without simultaneous tape punching, the full standard 4-bank keyboard with capitals and lower-case characters being available for this purpose.

The new *Tape/Card Reader FOL* 607 is making its first appearance in Britain; the Card Reader FOL 607 is manufactured by a Creed associate *Standard Elektrik Lorenz* of Stuttgart, Germany. The FOL 607 is a fully transistorised machine designed to read 5-, 6-, 7- or 8-track punched paper tape and edge punched cards at any speed from 5 to 70 characters per second.

At the exhibition the machine is demonstrated handling edge punched cards with a 5-track teleprinter code. The cards will be 7¼ in. $\times$ 3¼ in. in size and provide space for code-punching approximately 69 characters.

A unique feature of the FOL 607 is its ability to read tape and cards in both directions, whilst a manual "inching" facility enables the punched data to be read a character at a time when required.

We are informed that the *Model* 3000 *Tape Punch*, also on show, is now in regular production. Available as an optional extra on the Model 3000 is a check-back facility. This consists of a photoelectric component which automatically verifies that the data punched into the tape corresponds with that received from the computer. A positive safeguard against possible errors is thus provided even at the highest punching speeds.

The Creed *Model* 90 *Tape Verifier* has been recently introduced and is already in service. This is also exhibited.

Research for the Engineering Industry

The National Engineering Laboratory, East Kilbride, Scotland, is giving priority to research on several industrial problems of immediate importance, including investigations into computer control of machine-tools using moiré fringes.

Developed jointly by the National Engineering Laboratory and the National Physical Laboratory, the moiré fringe system can be applied to measure the errors in the movement of a machine and to control the subsequent movements.

The error signal obtained with this technique is fed into a servo-system and correcting mechanism, to reduce errors in relative movement continuously and automatically; in an experimental rig at *NEL*, incorporating a worm and worm-wheel drive, errors in transmission of uniform relative motion have been reduced by a factor of twenty. *NEL* has collaborated with *David Brown Industries Ltd.* in applying such an error-correcting system to the final table drive of a 30-in. gear-hobbing machine. This machine and gears of much improved accuracy produced on it was shown at the International Machine Tool Exhibition at Olympia, London, from 25 June to 8 July.

Moiré fringes are a type of interference band, produced when two similar transparent scales or gratings are placed close together with the lines of each scale not quite parallel. If one scale is moved at right angles to its lines, the fringe pattern moves along one whole fringe as the scale moves one whole spacing. The variation in brightness as the fringes move can be detected with a photocell. Angular movement can also be measured using radially ruled gratings; movement of one fringe then corresponds to the rotation of one radial division.

The method gives an accurate and convenient method of converting any change of position or angle into an electrical signal. Great accuracy is obtainable by these methods since the fringes are produced by an averaging process from very many accurately spaced grating lines. Another advantage is that the gratings do not wear; errors in the product caused by wear of a lead screw or gear no longer arise. In addition to their application to machine-tool control, moiré-fringe methods can be used for linear or angular measurement.

Errors in rotation of the work table of a gear-hobbing machine relative to that of the hob spindle have been measured by two pairs of radial gratings, one pair attached to the work table and the other to the spindle, each with a photoelectric measuring head fixed near it. The ratio between the line spacings in the two pairs of scales is the same as the displacement ratio of the table and spindle. The phase relation between the two photoelectric signals is recorded continuously on a chart to give both the error in relative motion and, after analysis, the source of error.

Automatic checking of pitch errors in lead screws up to 18 ft. long has also been achieved using a moiré-fringe technique. The screw is mounted above a horizontal precision girder along which is driven a carriage mounted on air-lubricated bearings. On the carriage is a 36-in. grating; a small grating of equal spacing and an optical reading head is fixed to the girder. As the carriage travels along the girder parallel to the screw, a chart record is produced which gives the error of each flank to an accuracy of 0·0001 in.

By a similar arrangement, the displacement of a carriage or any component moving in a straight line can be measured to 0·0001 in. over 10 inches. Moiré fringes are used also in the *Ferranti* (Edinburgh) system of computer machine-tool control.

NEWS FROM MANUFACTURERS

Complete Drilling-Boring Job "On Tape"

A multi-purpose, electronically-controlled drilling-boring-milling machine, capable of machining complex workpieces from start to finish without the attention of an operator, was shown at the International Machine Tool Exhibition (Olympia, 25 June–8 July), by *James Archdale and Co. Ltd.* of Worcester, a subsidiary of the *Staveley Coal and Iron Co. Ltd.*

The Archdale AUTONOMIC operates completely from instructions coded on the punched tape. Not only do the table and spindle head move automatically in the appropriate directions for each operation, but the complete machining cycle—including changes of tools, spindle speeds and feed rates—is performed automatically.

This exhibit, and boring machines exhibited by *George Richards & Co. Ltd.*, another Staveley subsidiary, incorporated new techniques evolved at the Staveley Research centre near Bedford.

With the Autonomic system, jigs are unnecessary and the operator has virtually nothing to do. The job starts with the usual drawing. From this is made a programme sheet expressing dimensions in numbers. These numbers are automatically coded and punched on tape in the office. The tapes are made of very tough material which will not tear. Should tape become damaged, a new tape can be produced from the old one without re-typing. In the workshop the tape is put through a tape reader which enables the special-purpose computer to take over and govern the operation of the machine without human intervention. On the Autonomic, there are scales to control movements in three axes simultaneously. The tape controls the machine in respect of:

(1) Positional or co-ordinate information.

(2) Depth information.

(3) Tool information.

The computer issues its command and the machine tool begins work. Feed-back impulses inform the control system what is going on, so that deviations are corrected and each operation is satisfactorily completed. Then the next command signal initiates the subsequent step in the operation, and so on, until the job is completed. Built into the machine are various refinements such as provisions for semi-automatic and manual control when needed for setting up and for relatively simple jobs.

Creed—75's in The Caribbean

The world's largest inter-island aeronautical radio communications system was officially opened in Barbados on 10 June 1960, by *International Aeradio (Caribbean) Ltd.*, linking ten of the Caribbean group of islands and extending from St. Kitts in the north to Trinidad in the south. The system provides integrated telephone and telegraph facilities and is designed to serve all airlines operating in the area.

The teleprinters used in the system are Creed's new Model Seventy-five, which is smaller and lighter than any other teleprinter in general production today, and also incorporates special facilities not available within other machines. It is able to perform a variety of operational tasks over and above its basic function of sending and receiving printed messages, without requiring complex and costly auxiliary equipment. For example, in the new Caribbean Islands communications system, advantage has been taken of the special facilities to provide a *selective calling* feature. This method of operation, somewhat similar to a telephone party-line system, enables network communications to be handled with greater convenience, economy and efficiency.

While it has long been possible for one teleprinter in a network of interconnected machines to send a message simultaneously to all the others, this can be inconvenient and time-wasting where the message being sent is of interest only to certain of the destinations in the network. In such cases, personnel at the distant stations are obliged to read all the received messages to determine whether there are any intended for them alone. The *selective calling* system which has been produced for the new Caribbean network overcomes this disadvantage.

Selective calling provides a means of sending a message from any one of a whole network of machines to any desired selection of the remainder. In the new Caribbean system information regarding the operation of the airlines in the area can be sent from any of some twenty-five offices to any selection of the remainder. Message traffic may be sent either manually or automatically. In the former case, the message is despatched over the circuit by typing directly on to the keyboard of the teleprinter.

With automatic transmission, the message is first punched into paper tape. This tape is then fed through a tape reader which automatically sends the corresponding telegraph signals over the circuit, using the selective calling feature to direct the message to the called stations. This method offers a substantial speed advantage over manual transmission, and provides an important reserve capacity for handling large amounts of message traffic.

An office, wishing to send a message to a number of other offices in the network, includes at the start of its message a special two-letter *calling code* specific to each of the required offices. The teleprinters at the called offices respond only to their individual calling codes and automatically condition themselves to record the ensuing message, while the teleprinters at the remaining unwanted offices lock themselves out of the circuit and warn their attendants by indicator lights that the circuit is busy. Once the message has been transmitted, the selective-calling sequence controls are automatically cleared down and the locked-out machines are returned to the common circuit. Indicator lights then advise all operators that the circuit is free and available for further traffic.

Recording of a message at the called station is completely automatic and does not require the attention of an operator. Incoming signals will switch on the teleprinter motor and switch it off again after the message has been received. If necessary, the incoming message can be recorded in punched tape form in addition to the normal printed page copy. Special test facilities are incorporated in the office equipment to enable the operator to carry out quick checks of the tape reader, the line, the VF terminal and his local teleprinter.

Although all the selective-calling control units are of

identical construction, they can be set to respond only to the messages which include their particular calling code, by moving five links on a built-in plug board. This design feature eliminates the need for complicated wiring changes when a faulty control-unit needs to be replaced, since any reserve control unit can be set up easily and quickly to function in any of the twenty-five regional offices.

"GC Panellogic" Control Panel Wiring System

A completely new approach to the problem of Control Panel Wiring for Punched Card Systems, called "GC PANELLOGIC," is now being offered by *Punched Card Accessories Limited*, in association with *Calibrated Papers Limited.*

The GC PANELLOGIC system comprises all the tools and materials needed for the planning and wiring of most types of Plugboard. Components are supplied either in a handy portable kit or separately as required. By means of the hand tool provided, wires are cut and connected in exact lengths, making neater, more compact Plugboards. Ten different wire colours allow for complete colour coding so that wiring can be traced visually, and circuits tested and checked from the terminal posts without removing wires from the panel, or panel from machine. Wiring costs are, of course, materially reduced.

The Friden 82-*Character Code*

In order to make it possible to use a *Friden* Flexowriter in conjunction with a computer, *Friden* have evolved a 5-channel, 82-character code so that tape produced by a computer can be used to produce a document on a Flexowriter.

Whereas the normal 5-channel code only provides sufficient codes for the alphabet in letter shift and a further 26 characters or functions in figure shift, the *Friden* 82-character code, by making a further breakdown in each shift, allows both upper and lower case characters to be printed plus 12 numerals (0–11), 3 fractions, 10 symbols and 5 punctuation marks, making a total of 82 characters.

The keyboard has a total of 51 keys and of these upper case (2), lower case (2), tab, carriage return and back space account for seven. Of the remaining 44, one is used for changing the colour of the ribbon and one each for letter and figure shift codes, leaving 41 printing keys, each of which prints two characters.

Two types of ribbon-colour changing devices are available. The first requires one code, which, when read by the Flexowriter, changes the ribbon from one colour to the other. However, there is no knowledge of which colour is being printed, only the knowledge that the colour has been changed. The other device requires two codes, one for each colour. Here the ribbon only shifts from black to red when a black code is read and vice versa. This version does not need a key and therefore allows two further characters to be printed.

From an operational point of view the machine is ideal for producing documents off line from a tape punched by a computer, as the punching in the tape of letter and figure shift codes and upper and lower case codes is controlled by the computer program.

This latest *Friden* development is the result of co-operation with computer manufacturers and users in the United Kingdom. Enquiries should be addressed to *Bulmers (Calculators) Limited* in London, or at their provincial branches.

Friden ACPT Add Punch

The *Friden* add-punch is basically an adding machine with a tape punching unit. It lists each item and amount on an adding machine tally roll, while punching the figures into a punched tape using the eight channel code. At the same time, selected data may be automatically punched for subsequent automatic processing, such as sales analysis codes, production and inventory control codes and functional codes for the tabulation of statistical data or transmission by wire.

The latest model of add punch has several improvements over the earlier type. These are:

1. A removable control panel which can be changed in a few seconds. This enables an unlimited variety of programs to be used.
2. Removable diode board, to enable the machine to be used with 5, 6, 7 or 8 channel tape.
3. New wide platen (5 in.) for rear feeding.
4. Odd (or even) count parity check to ensure accuracy of punched tape.

These new features are added to the established advantages of the model APT add punch some of which are listed below.

1. The field size for each activating key is controlled by control board wiring, permitting the length of readout fields to be varied by depression of different function keys.
2. Six possible programs can be selected from the function keys.
3. The tape feed key can be wired to punch any code or codes selected by the customer.
4. The operator cannot get ahead of the punch speed, which is 1,400 digits per minute.
5. Zeros can be selected or suppressed preceding selected digits to be punched.

LEO Enters the Lion Country

The first commercial electronic computer service in Africa is to be established in Johannesburg by a new company, LEO *Computer Services (Proprietary) Ltd.*, formed by LEO *Computers Ltd.* of London, and *Rand Mines Ltd.*; it will be operating by April 1962.

The installation, costing over £250,000, will comprise a LEO III Computer (the advanced all-transistor model which was first announced in mid-June) and will be equipped with a very large magnetic-core storage system, to facilitate commercial data processing. Input to the system will be by punched paper tape and punched cards; output will be by paper tape, punched cards and a high-speed printer operating at 50,000 lines an hour. High-speed multiple magnetic tapes with immediate automatic checkback will provide intermediate storage.

We have been informed that several large organisations have already indicated their desire to use these services. Among them, Rand Mines is considering the processing of payrolls and stores-control for their gold mines in the Witwatersrand area. A wide range of technical problems,

including ore-reserve valuations and assessments of the economics of mining operations, is expected to be handled by the new installation.

LEO *Computers Ltd.* will make available its unequalled experience of commercial data-processing to the new company, the chairman and managing director of which will be Mr. F. E. Hay, a manager of *Rand Mines Ltd.* LEO *Computers Ltd.* will provide a bureau manager, a chief operator and a chief engineer as the nucleus of a fully-trained and experienced staff in Johannesburg.

The new Company will also market LEO Computers in South and Central Africa, including Northern and Southern Rhodesia and the Portuguese territories adjoining. It will also provide a maintenance service to purchasers of LEO installations.

Computer Aids Inter-Continental Communications

The National-Elliott 405 computer at Australia's First National Electronic Data Processing Centre, officially opened in February 1960, is being used by the Department of the Interior's Ionospheric Prediction Service to forecast the best times to send overseas cables or to make radio-telephone calls.

Hitherto, the complicated calculations required for this work were done by a team of mathematicians using variable data coming in from 60 stations throughout the world. It took five years by manual methods to revise the Service's basic predictions for the world. Now the 405 computer will do the whole job in one hour every two months—a total of six hours a year.

THE COMPUTING LABORATORY IN THE TECHNICAL COLLEGE

A two-day Conference on this subject was held at Hatfield Technical College on 27–28th May, 1960. It was organised by the Department of Mathematics of the College and was attended by about 130 persons from 62 colleges and 12 institutions and firms, as well as by a number of persons *ex-officio*. The *object* of the Conference was to consider the purpose, equipment and use of a computing laboratory in a technical college, with particular reference to the effect of computing machines on mathematics today.

After the Principal of the College, Dr. W. A. J. Chapman, had welcomed everyone, Sir Graham Sutton, Director-General of the Meteorological Office, spoke on Applied Mathematics and Computing Machines. He talked particularly about the use of computers to carry out genuine experiments in applied mathematics by making calculations on ideal systems simulating complex real systems. Dr. J. Crank, of Brunel College of Technology, then spoke on the New Significance of Computation in Higher Technological Education. He said industry is now finding mathematics *useful*; the results were changes in mathematics and in the kind of mathematical education those working in industry had to have.

The Friday afternoon Session was devoted to The Contribution of the Computing Laboratory to the Technical College Curriculum. It was opened by Mr. P. G. Barnes, *de Havilland Aircraft Co. Ltd.*, speaking on Industry's Requirements. He said mathematics and computers provided tools for getting results quickly and accurately but the power provided by computers might be lost through bad computing techniques. Industry increasingly expected its staff, both scientific and commercial, to be able to use mathematics and computers as tools, and to this end it was important that students be taught to think as much in terms of numbers as in mathematical symbols. A "feeling for numbers" must be inculcated. Dr. S. H. Hollingdale of the Royal Aircraft Establishment spoke about the way the advent of computers and the growth of operational research and mathematical statistics had in recent years led to a large increase in the demand for trained numerical analysts, computers and statisticians at various levels and of the efforts initiated by R.A.E. to design suitable courses of training in these topics. Mr. Richard Goodman, Secretary of the Automatic Programming National Information Centre, gave some thoughts on teaching programming and considered in particular the difficulties facing colleges without a computer of their own.

During the first part of Saturday morning, The Technical College Computing Laboratory as a Computing Centre was discussed. Mr. T. Vickers of the National Physical Laboratory discussed the organisation of a computing centre and gave examples drawn from his experiences at N.P.L. and elsewhere. He was followed by Mrs. M. M. Barritt of the Royal Aircraft Establishment on the organisation of a computing laboratory. The substance of her paper is to appear in a subsequent issue of the *Bulletin*. The second half of the Session was devoted to the Technical College Computing Laboratory and the Schools. Dr. J. M. Hammersley of the Institute of Statistics, Oxford, spoke about the impact of forthcoming developments in computers on both school and college mathematics.

The final Session of the Conference discussed equipping and financing a technical college computing laboratory. Dr. J. R. Barker, Imperial College, gave an account of his mathematical machines laboratory and of the manner in which he used it to strengthen the mathematical education of engineering undergraduates. Mr. C. E. Jackson, H.M.I., said he thought he could assure the Conference that the Ministry of Education was anxious to see that computers took their place in college work but they were very expensive and one had to justify their acquisition.

The Conference was closed by the Principal.

During the two days of the Conference, *Ferranti Ltd.* exhibited a SIRIUS and *Elliott Bros. Ltd.* exhibited an 803 and an analogue computer. Well over 60 members attended each of the lecture-demonstrations given on these machines on the Friday evening. About 40 members visited *Standard Telephones & Cables Ltd.* for lecture-demonstrations on a ZEBRA on the Thursday evening before the Conference and on the Friday evening. In addition, Solartron and E.M.I. exhibited analogue computers, and Archimedes-Diehl, Brunsviga, Facit, Marchant and Muldivo-Madas exhibited desk machines. *Scientific Computing Service Ltd.* arranged an exhibition of mathematical tables and books on computing, etc., and gave demonstrations of desk computation.

Editorial

ARCHIVES

Now that the second generation of computers is moving into action, it may be time to take a look backwards at the pioneer machines and those of the first generation.

PILOT ACE stands in the Mathematical Section of the Science Museum at South Kensington, looking somewhat isolated among the desk-calculating and early punched-card machines. Perhaps one day it will be joined by friends from Cambridge and Manchester.

Can the Society in the meantime play its part in the preservation of the literature? Its Library must certainly try to obtain the reference manuals of the historic machines, and we venture to appeal to members to help.

In his amusing article "For What Its Worth" in our last issue, Mr. G. J. Tee (we apologise for the misprinting of his name) drew attention to earlier computing devices. It may well be that there is considerable original descriptive material in existence referring to automatic computing development over the last two hundred years. The Society need not hesitate to offer a permanent home in its Library to all such documentary references.

Finally, we come to the present-day computers. The Library has only fragmentary documentation of these. May we suggest to our friends, the computer manufacturers, that this state of affairs needs putting right?

Note: The address for this literature is:—

The Hon. Librarian,
BSC Archives Section,
Leicester College of Technology,
Leicester.

COMPUTER COMMENT

Programming Techniques

After the Annual General Meeting, a paper was read by Mr. R. W. Bemer of *IBM*, New York. Under the title of "A Survey of Modern Programming Techniques," Mr. Bemer covered a wide range of subjects in some detail in the space of an hour. Taking the topic of programming languages as a centre, he ranged over the construction and assessment of translators, techniques and requirements for operating very fast computers, programming techniques and the design and standardisation of data codes.

Mr. Bemer suggested that the engineering design of computers was very much in advance of the capability of programmers to use them; new programming techniques were needed in order to catch up. In the development of a standard universal language, which might be available within two years, essential characteristics were the possibility of describing the language in its own terms and of defining terms and procedures recursively.

The work of writing translators was being considerably reduced by the development of scanning and list-processing procedures and by analysis languages which could be used to to define problem languages and translating procedures. With the development of faster and more flexible computers, interpretive procedures were regaining ground from compilers.

To make use of the increasing speed and power of computers there would have to be a shift from human towards automatic operation. To achieve this, the machine must have access to all its own states. There would be a heirarchy of control with a single on-off switch as the final level. Computers would test themselves and make provision for their own repair; programs would be automatically adjusted to make optimum use of the equipment currently available. System time would be automatically shared among remote users and automatically logged.

Discussion was somewhat limited, possibly due to the range and comprehensiveness of the paper. Even Mr. C. Strachey was reduced to a brief and rather respectful question. In reply to this, the author suggested that future high-speed storage requirements for translators might not exceed 16,000 words.

Mr. Bemer's paper is to be published in the next issue of *The Bulletin.*

* * *

C–E–I–R

A new comer to the computing field in the UK is a recently formed company, C–E–I–R (UK) Ltd., which is a subsidiary of the *Corporation for Economic and Industrial Research* (C–E–I–R Inc.) of Arlington, Virginia, USA. C–E–I–R has recently announced agreement with *IBM United Kingdom Limited,* over the setting up of a data centre in the London area which will incorporate an IBM 7090/1401 System, and on which C–E–I–R has contractual full operating rights. The equipment, which was on order for C–E–I–R Inc., has been released specifically so that *IBM United Kingdom Limited* can afford C–E–I–R (UK) facilities comparable with those operated on the C–E–I–R 7090 installations in Washington and New York, and with other, not less powerful installation, later to be operated in Houston and Los Angeles.

Whilst C–E–I–R rents out computer time to customers, as is done by many of the actual machine manufacturers, this is not its primary function. In the US it has an extensive business in formulating and solving problems for management, making use of the latest computing techniques (and computers) to assist in this work. It employs many first class programmers and mathematicians, amongst whom are W. Orchard-Hays and J. Moshman (Vice-Presidents) who both are prominent members of the ACM.

Illustrative of the varied work of C–E–I–R is (i) the production of a report for the US Senate on the Soviet bloc Latin American activities and their implications for US foreign policy, (ii) the determination of the best maintenance

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schedules for aircraft of the US Navy, (iii) the production of bus and train schedules for local operators, (iv) the setting up of a service for power companies to analyse transmission systems, and (v) the solution of mixing problems in the food and oil industries.

Formulation of problems, definition of methods of solution, and programming solutions of problems and the collection of data all come within the activities of the Corporation, which is currently working for several major oil companies, a number of Government agencies, and many large and small firms in the US. These services will now be available to British industry through the UK company, and a suitable British staff is being built up from within the UK to afford the necessary facilities to clients.

Chairman of the UK company is British born Dr. Herbert W. Robinson, the President of C–E–I–R Inc. A distinguished economist and statistician, who was educated at LSE and Balliol, and who served on Lord Cherwell's staff in the War, Dr. Robinson emigrated to the US in 1943, and founded C–E–I–R in 1954. Vice-Chairman is Dr. C. O. George, himself a statistician and formerly at the Board of Trade. In a recent interview Dr. George commented that the availability of the installation in London would be of immense benefit to business in Britain. Although vital to big business and large-scale research it could also be used profitably by a wide range of medium and smaller businesses who could use facilities otherwise beyond their reach. Some dozen IBM 7090 systems already operate in the United States, but, so far, almost all except the two installed for C–E–I–R Inc. in New York and Arlington are reserved exclusively for use by the US Government on such works as Defence, Communications, Space Research, and other complex problems.

Stressing that C–E–I–R is an entirely independent organisation, unconnected with any manufacturers of computing systems, he said: "Computers, as such, are not our business: we neither make them nor sell them. But we have in our organisation the world's largest independent collective experience of their practical use in the solution of management problems."

Managing Director of C–E–I–R– (UK) *Ltd.* is Mr. T. Cauter, a former managing director of the *British Market Research Bureau* and, until recently, Director of Marketing for *W. R. Grace*, a US firm making a wide range of products in the paper and chemical industry. Technical Services will come under the direction of Dr. A. S. Douglas, a former member of Council, until recently Director of the computing laboratory at Leeds University.

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Visit to Ford Motor Company Ltd. Spare Parts Division

On 8th September 1960 a small party of members of The British Computer Society were shown round the *Ford Motor Company Ltd.* Parts Division at Aveley, Essex, which uses a LEO II computer to control stocks of 45,00 lines of spare parts; of these approximately 10,00 move every day and 20,00 are active per month. The division deals with approximately 400 Home and 400 Overseas customers.

Urgent orders are received typed or written individually on the standard forms supplied by the Company. Bulk replacement orders from Home Main Dealers are received on Stock Order Sheets, in books, known as "MSO Pads," returned to the Company once per month in accordance with a rota. There are approximately 30,000 computer movements per day—for all movements except those related to bulk Monthly Orders, cards are pulled from a Master File in accordance with the Ford Part Number which is interpretive. In the case of the last mentioned, card pulling is obviated by punching on blank cards Page and Item No. from the MSO pads, and collating these cards with a master pack of cards which carry all standard information relative to the part. The computer uses a non-interpretive serial code and this code number is punched in master cards. It is a six digit number, which will be sufficient, it is estimated, to cover requirements for several years ahead.

Receipts of goods of varying type and other types of Stock Adjustment Movement Cards are sorted on a preliminary run, using separate card sorting machines. The stock position is held on a master card file, in binary form, but only the Stock Records card of moving items are fed into the computer on each day's run.

The computer is switched on 24 hours a day, of which approximately 3½ hours are used for preventive maintenance, 1½ hours for program development, leaving a further 1½ hours spare in case of failure.

The following major runs are carried out on the computer:

(*A*) *Run:* Check availability. For items available, clear the transaction for picking the item from stock. For non-available items, punch a Back Order Card to carry forward all data regarding amount required, etc.

(*B*) *Run:* Prepare triplicate invoice, priced and extended for picking item from bins. (Any failures by the Depot at the picking stage, to find an item shown on the invoice, are annotated in pencil and later investigated.)

(*C*) *Run:* Prepare Export documents. For Export, one document is used to pick each item. Invoices are prepared for each case by typewriters, because of the complexities arising in Export business, e.g. market and Customs requirements. About four times as much computer time is required for each Export item as for each Domestic item.

It was explained that as a result of greatly increased volumes the system was handling considerably more work than had been envisaged when the original design study was made in 1955/56. The current system has absorbed the small punched card installation which originally handled the bulk Monthly Orders (MSOs). Along with other types of orders, these are now pre-posted, whereas, before the advent of the computer, manual post-posting was practised. The use of a computer has made possible many additional refinements.

Fords were investigating various computers with larger immediate-access stores, which would be capable of applying such techniques as exponential smoothing and automatic determination of stock levels. A separate Material Control Department determines the re-order level of each item. They had found that as the computer system started to operate, new requirements were continually added to the program.

The majority of transactions are pre-posted by the system outlined above, but in the interests of customer service, urgent orders are passed immediately to the Stores for picking, and these are posted to the stock records after dispatch.

After a conducted tour had been made of the Computer Section, a vote of thanks was passed for the very detailed information and hospitality which the *Ford Motor Company* had provided.

REFLECTIONS ON THE IDP MISSION TO USA

by J. G. Grover

This article contains the random reflections of a member of the European Productivity Agency's *mission to study integrated data processing in the* United States, *under the aegis of the OEEC during April/June 1960. It is based on a talk given to the Birmingham Branch of* The British Computer Society *on 19 October 1960.*

Introduction

These are random recollections resulting from membership of the recent European Productivity Agency mission to the United States to study integrated data processing. In this context my own interest lies in the application of computers to commercial operations in industry so that it is in this particular sphere where most attention will be concentrated. It may therefore be assumed that I am no technician and can offer little enlightenment in detail on the subject of current technological development.

It would be right and fair to say that comparatively little came to the attention of the mission on which some of the whole group were not already informed to a greater or lesser extent and with varying degrees of accuracy. It would, in fact, be a very poor reflection on the adequacy of international communications in the present-day world if such were not the case. It is, however, immeasurably reassuring to see those things happening on the ground which one has read about and to know for certain that science fiction is but a small fraction of our complex structure.

One is apt to forget that the application of electronic computers to business problems is scarcely ten years old. Some measure of the technological advance during this period can be gathered from the statement made that a computer of similar power to the original Univac can be purchased today at one-sixth of the price then prevailing. There can be no doubt whatever that this reduction in price is not due to the fact that manufacturers have successfully written off development charges against profits already received! It is probable that the extremely rapid advances made have only been exceeded in the worlds of atomic energy and the exploration of space. It is equally to be hoped that some of the misapplications which have occurred in the computer field are unlikely to be repeated in those other spheres where rather more catastrophic repercussions could result.

Rapid Advances in Miniaturisation

Technicians, and one is forced to assume, users, will not be satisfied until the giant proportions of that original Univac machine are reduced to the size of a package of cigarettes which will bring in its train the sheer physical impossibility of carrying out any maintenance at all except on peripheral equipment. What effect this may have on costs and on manufacturers' profits is a little difficult to foresee because, in conjunction with a reduced size, the standards of reliability are improving enormously so that a replacement may be more extensive in terms of its functions, and possibly in its price, but its life should be much longer. It was refreshing to find, at some installations, that preventive maintenance is now beginning to be relegated to the week-end with the consequent freeing of valuable time in the week for productive work and for the easing of the time schedules which always tend to get worse as applications grow in number and in the degree of their integration.

One of the reasons for these improvements is, undoubtedly, the increased use of transistors, core storage, tunnel diodes, and other compact devices. These are not only more reliable in themselves, but their electronic simplicity enables tape units and other ancillary apparatus to be plugged into the main machine and consequently to be replaced complete, while maintenance or repairs are being effected in the workshop without the corresponding down-time on the main installation. Another aspect of this development from the user's point of view is the consequent ability to expand the size and power of his equipment to meet his own demand as it may become necessary. This should avoid some part of the rental or capital charge for unused equipment before it becomes operational and may help the installation manager to keep this major item of cost relative to the work which he is doing now rather than what he hopes to do in some years to come. This may help to avoid the temptation to become operational before the job is really ready, with the consequent establishment of a program, or complete procedure, which may be somewhat inefficient. One impressive installation was seen where the capacity of the core storage had been doubled over the week-end and where eleven tape units had been added, also over another week-end, thus enabling uninterrupted working to continue on a two-shift, five-day week, loading. One has only to remember the prolonged anxiety arising during initial acceptance tests of early machines to appreciate the success of this operation and the very small amount of testing time which it was planned to provide and still achieve the requisite high standard.

Greater Speed

Another ever-present factor in computer development is the continual effort towards increased speed. Among the new models coming on the market all reflect this increase, with one or two notable exceptions where speed has been sacrificed for price. It is sometimes argued that speed is of little significance in the commercial operation as compared with the complicated scientific calculations where problems now being successfully tackled were beyond our reach only a few years ago in terms of the actual time required or the value of the answer relative to the computing time. It is suggested that speeds already available through computers used for commercial work are so far in excess of other office machinery used in data processing that the saving of a few milliseconds in each operation is comparatively insignificant. There are several reasons which combine to throw some doubt on the truth of this statement. Firstly, it may be taken as a general rule that overall operating times for a program

will exceed the original estimates. As the machine loading becomes more complete this factor has increasing significance. Secondly, there are many instances, particularly in government, banking and insurance installations, where it is the sheer volume of the operation which has made its application to a computer an outstanding economic success. Speed is of significance in all such operations. Thirdly, the economic climate within which computers have been operated on commercial work has been one of expansion. More than one installation was seen where routine invoicing work, for example, has been steadily increasing at a high rate over a period of years with a corresponding distortion of the original time schedules. In all these instances speed is possibly one of the solutions to the problem.

These factors of increased reliability and speed are equally apparent in peripheral equipment as well as in the main body of the computer itself. Printers operating at 600 lines a minute are not only common, but probably even predominate numerically. Technical improvements are rapidly leaving these speeds behind (6/10,000 lines per minute are now possible), but, as has occurred in the past, it is the mechanical handling of paper which offers the most difficult problem. The sheer volume of paper being produced is a little frightening and one cannot help wondering whether the application of exception techniques is not perhaps too infrequently applied and whether the acceptable limits set in relation to these techniques are not perhaps too narrow. Users frequently stated that satisfactory limits can only be determined by prolonged trials and that reconsideration would be given in due course. While this may be true, reconsideration can easily be overlooked in an operation which has been mechanised and become routine.

A card reader operating somewhat in excess of 1,400 cards per minute was seen under working conditions. It was most interesting to see the effects of a bent leading edge in a card to be read; the whole operation came to an immediate, but smooth, halt, the offending card was extracted, the edge smoothed with a quick stroke of the thumbnail and work went on from the stopping point. One has only to compare this with the catastrophic effects of a similar mishap with high-speed card sorters to appreciate the validity of the direction of some technical advances.

Character Recognition

The battle between magnetic reading and visual scanning continues with considerable development and much professional interest on both sides. No doubt there are and will continue to be applications ideally suited to one or other approach. There can be no doubt that any solution to the conversion of raw data to machine language would be preferable to the existing state of affairs and it is good to know that progress is being made.

Data Transmission

Some of the more impressive technical advances, at least to users from this country, lie in the field of data transmission. This is more commonly achieved through punched tape with card/tape or tape/card conversion than by direct card reading/transmission/card punch, mainly because of the comparatively slow card punching speeds available. The accuracy of transmission is high with an error rate well better than 1 in 800,000 in terms of bits. This was confirmed by several users, including one where 19 warehouses were linked to a central point from very widespread localities involving distances vastly greater than those in this country. Their figures, incidentally, covered a period where an act of God, in the form of a severe storm, had completely obliterated one trasnmission. As a result of this type of experience, error correction devices do not seem to be the subject of development, reliance being placed rather on error detection, either through automatic or by accounting checks, followed by re-transmission where necessary. Speeds in general are high; 1,000 bits a second, but very much in excess of this figure under laboratory conditions.

Speeds of this magnitude are diverting attention from paper tape units to direct transmission and recording to and from magnetic tape. While this is not yet in general use, it has passed beyond the laboratory stage. Such tapes can be readily used to operate high-speed printers quite apart from the computer, a possibility which offers considerable advantage to a large central computing station backed up by locally printed results or, alternatively, local tape records with simple electronic devices for updating purposes and rapid transmission to a central processing unit.

There is emerging from the pilot plant stage a most interesting development in the use of microwave transmission direct from magnetic tape to tape at speeds in the order of 100,000 bits per second but, it was said, with theoretically calculated possibilities exceeding 100 times such speeds. The immediate drawback is one of cost resulting largely from the necessity of erecting a network of dish reflectors to achieve "line of sight" communication. One of the telegraph companies already has such a network available for its customers' use on the east coast and which is expected to be trans-continental by next year. It almost goes without saying that the next stage of development is well in hand—that of using satellites to give a wider range than can be achieved by earth-bound reflectors. At the present time the project does not appear to have the necessary priority on the launching platform to achieve a world-wide coverage in the immediate future.*

It is perhaps a little idle to compare the rate of development across the water with the present state of affairs at home. Here the facilities available to the user are slow and inaccurate and microwave development is so controlled as to be difficult at the very least. Development of devices for automatic error detection and correction, which appear to be unnecessary on the other side, are spoken of in hushed voices. One is told in the USA that the rapid rate of progress being made is one of the fruits of free enterprise and that without competition comparable results are not to be easily achieved. The implication is rather misleading since here there is much private enterprise devoted to such development, but its transfer to the field and, therefore, its availability to the using public, is possibly hampered by red tape. One cannot help but feel that there is no monopoly of technical ability and that its co-ordination and direction might even be more readily controllable in this country. It may be that there is lack of capital for this type of research and development, but it also seems fairly certain that there is a considerable lack of public relations on what has already been achieved, what is being attempted and its state of readiness for public use.

* This paragraph was written before the successful launching of the communications balloon satellites in August and October 1960, on which congratulations are to be offered. It is to be hoped that these efforts will be followed by further satellites, so put into orbit and spaced, that world-wide communications networks may be available. This would be an outstanding performance indeed, both technically and, it may be hoped, in international co-operation in the use of these facilities.

Movement of Data within the Organisation

In the general field of communications some interesting examples were seen of internal transmissions operating between, the factory floor and a central data processing unit. In one example, static data was held in the form of a plastic punched card containing the individual's clock number, job identification, etc., which was inserted into a reader, and the variable information, time or number off, was dialled into the circuit and the composite information punched into a tape at the centre. It would be wrong to give the impression that these installations are common. They are still in their infancy, but the general impression received was that the results seemed to be more satisfactory than had been previously achieved through mark-sensed cards, but that there was still some way to go, particularly in the proper method of use and the appropriate training of personnel.

Real Time Applications

This brings one on to the consideration of the use of computers in real time. This is being done in miniature at almost every airline ticket office one visits where reservation inquiries are made by a punched metal or plastic plate, backed up by push buttons for inquiries. The answers are, for practical everyday purposes, almost immediate, but the complete file record is only a computer in the elementary sense, the emphasis being essentially on storage capacity.

One of the most striking talks heard was that given on the computer procedures and machinery at Cape Canaveral. Here the actual and predicted course of each missile launched is worked out with a sufficient margin of time to enable the authorities to explode an offender should it go off course and become a public hazard. To those who have had personal dealings with early computers this cannot but present a very sobering train of thought, even though the standard of achievement appears remarkably good.

The general impression was that real time operations are still a long way off and probably of doubtful economic value as yet.

Time Sharing

Progress is being made in work of an allied nature—that of operating more than one programme at the same time with suitable priority switching to avoid delay in the main effort. On one University computer this was being done to provide serious research work (and also income from service work) while giving programme training facilities to students on an appropriately lower priority rating. In commercial operations this would probably necessitate a rather more powerful installation than would otherwise be necessary since, in the ordinary commercial application, this difficulty can often more easily be met by reasonable interrogation facilities. This concept may be of value to large service bureaux but seems of doubtful economic justification to the average industrial user at the present time.

Operational Research Influences

As regards actual commercial computer applications themselves, there appeared to be, as already stated, nothing that was really new or startling. There is, however, a very great deal to encourage solid confidence in the future of the computer in this field. Such new work as was seen often consisted of the extension of an original application to incorporate operational research techniques as a part of the routine. This does not mean that the basic application itself was new, but that new techniques were employed in the solution. It was no part of the mission's work to examine, in detail, the reasoning behind such solutions, but there is little doubt that the techniques are yielding very beneficial results and that there is a very wide interest in this approach.

Business Users

In the USA there is a very large group of comparatively small companies using computers on regular commercial operations. In every instance it can be said that these users are satisfied with the results that they are achieving at this stage. Many of them are showing less economic advantage than had been anticipated, but the intangible benefits appear to be both satisfactory and substantial in that they would not be willingly discarded. Even in the most marginal cases the expanding economic climate is increasing both the necessity and the profitability of the installation, so there is no indication whatever of any regression away from computers. In fact, the general impression gained is one of optimism. The initial plunge into the world of electronic data processing has brought confidence in the equipment itself and in the ability of good staff to handle it to give satisfactory results. Almost everywhere the emphasis is on the plans for what is to be done next and in the foreseeable future.

It is possible to divide the larger users into two separate types—those who have a very large bulk data handling problem such as occurs in banking, insurance, public utilities, etc., as already mentioned, and those, while still concerned with the bulk of some aspect of their business, are facing a wide range of completely different problems covering such aspects as production control, scientific work, invoicing and inventory control; everyday problems which face every industrial unit.

The former type of user is achieving some extremely successful and economic results, largely resulting from the increased speeds available through computers. It is an over-simplification to say that the methods employed are an extension of punched card procedures. It is probably true that punched cards preceded the computer in such instances and that the conversion has not proved an outstandingly difficult problem so much as one of time, care and patience.

Among the other group of users this is not so frequently the case. More often the previous use of the punched card was limited to those areas where bulk was presenting a problem, but this was only one problem among many that required solution. It is in this situation that the industrial computer practitioner most frequently finds himself and which offers to him a very real challenge.

Approach to Integration

To judge from past literature, which is mainly of American origin but does not necessarily represent American practice—a state of affairs by no means limited to that continent—the recommended solution has been a complete and detailed survey of the whole field with a resultant integrated scheme of procedures which will use each single piece of data in every way required, from the cradle to the grave and thereafter embalmed into historic records for further future analysis. This approach has been successful, although no one concern was met which had as yet achieved the complete goal. Nevertheless, very impressive progress has been made.

It seems that the more general approach today was one

with similar objectives but with a change of emphasis, although here, again, no one had achieved the final goal. The overall integrated plan is good but only as a general guide, acceptable to management and representative of the probable parameters of the complete operation, in just the same way that it may be advisable to know what one wishes to achieve before embarking on any project. To get involved in detail at this stage is an error of judgment because the plan will take many years to accomplish, and during this period changes will have occurred in the legal framework, the national economy, the industry itself and, above all, within the unit in that industry; none of these changes having been entirely foreseen. Similarly the facilities at one's disposal will have changed so that the method of approach in detail may become inadmissible before the practical work is substantially in hand. It would appear better to select an area of operations which is going to offer a quick return, at the same time being prepared to integrate other operations into the initial efforts: in fact, to reinforce success in any direction.

In parenthesis it may be emphasised that integration is not restricted to office procedures and data alone; it has its place also in shop floor methods. At one installation visited a despatch advice was printed for each order to be despatched, coded to indicate a suitable sized container. Each container and advice note travelled over a standard route through the warehouse by conveyor belt, the items required being placed in the container so that the order was complete when it reached the packing point. At another installation, dealing in engineering spares, a block of despatches were analysed and aggregated by part numbers and the total requirement to meet the blocked orders was collected from the warehouse bins by truck and delivered to the packing point where each individual despatch was assembled. Both different methods suitable to the product being handled, but with the physical factors integrated with the paper work involved.

One essential feature is to get confidence from practical experience and this may be achieved through mathematical work, as in the aircraft industry, through bulk data handling, as in insurance, or even through sheer determination, as in some cases where the initial application has proved to be disappointing in itself. In addition to experience this method offers the advantage to management of some return on its investment and enables them to spread the organisational changes, which will undoubtedly prove necessary, over a longer period. The main disadvantage lies in the technical programming of the computer. This type of approach calls not only for the completion of a satisfactory program proven by results, but also the retention of a program maintenance team who will keep the completed operation up to date with changing conditions and will also knit in the integrated aspects of other programs being, or to be, produced.

Program Maintenance

Some users of long experience complained bitterly of another use to which their program maintenance teams were perforce put. The introduction of a new computer giving more scope, more power, greater flexibility or, in some other way, helpful to current and planned applications, and which usually called for a complete re-programming of existing procedures.

One user stated that this had now happened to him three times in nine years and that the introduction of yet another computer was regarded with considerable apprehension. There appeared to be no doubt but that the additional installation facilities would make the effort worthwhile on economic grounds alone, quite apart from the new possibilities which would be opened up for work not yet developed. This state of affairs is one of the reasons accounting for the very marked differences in staffing as between this country and the USA where systems development and programming personnel are very much more numerous. If this is the solution then installation management must anticipate a steady or, more probably, an increasing, salary bill in this branch of computer work rather than a diminishing one which is sometimes expected to be achieved as the installation becomes more heavily loaded and the applications more static.

Automatic Programming

As is frequently the case, there is a ray of hope on the horizon coming, in this instance, from the increasing development and use of semi-automatic coding procedures. There can be no doubt that these developments are successfully reducing the programmer/coder's training time to a few hours, and the time taken to produce a final computer program from the developed procedure can be reduced in the order of 15 to 1. The purist will say that this is at the expense of some efficiency, and this is frequently true. However, the loss is frequently small compared with the benefits from becoming operational more quickly. It is stated that, in a long program, efficiencies in excess of 100% can be achieved because of the inevitable deterioration in personal application over the very long periods necessary under completely manual methods.

A very big effort has recently been directed towards the development of a universal code of this type for which all manufacturers in USA are being pressed to develop their own individual interpretation program. This project is being energetically pressed home by the US Government and certainly the concept appears excellent and should stand a very considerable chance of success although, personally, there has been no opportunity to digest the proposed vocabulary. There is a further effort now in hand towards producing this vocabulary in an international language on the lines of Esperanto.

There are many advantages to be gained from this development in particular and from auto-coding in general. The large user can have compatibility of programs as between computers of differing capacity, or even of different manufacture, at outlying points as compared with a central processing unit. Easy convertibility could considerably encourage the use of service bureaux where programs can be developed and explored on a service machine without restricting the customer's choice of installation at a later stage. Departmental and installation management can be more easily informed on the detailed steps used to cover particular aspects of an application in which they have a personal interest. Another great advantage is the possibility of quickly writing short programs for testing new procedures or techniques, mathematical models and similar one-off projects where manual methods can be very protracted.

Stimulus of Government Interest

Although it is appreciated that this new development will be of immense value to Government Departments in making programs compatible on a wide variety of installations and in integrating data of value to a number of different departments, it is no more than symptomatic of the US Government's general attitude towards development of all types

throughout the whole computer field. In any country the Government is almost certainly the largest potential user of computers and has a corresponding interest in peripheral equipment, special purpose programs, a wide variety of applications, integration of procedures, communications, and allied matters. A great deal is being done by the US Government to foster development by direct contract and through purchase or rental on similar lines to private users, as a result of which there were, at 30 September 1959, 327 computers installed or on order for Federal Government work. As a corollary of this a great deal of time and effort is expended on keeping the interested section of the public informed on governmental experience and achievement. By comparison there would appear to be scope for improvement in the attitude of Governments of other countries.

As a result of this open-minded policy it was possible to pay a most interesting visit to a senior official at the Pentagon. As a side line to this experience it may be some comfort to learn that the widely publicised computer fire of last year did not start in the computer itself but was a result of some building alterations in the immediate vicinity. Nevertheless, the lessons to be learned concerning tape data storage are just as valid and perhaps the more impressive because they come, as any visitor to the US will have observed, from a very fire conscious country.

Training Facilities

A word would not be out of place on the very wide-spread educational facilities available, not only to those primarily interested in computers as such, but as a regular aspect of training in business administration and in commerce generally. The more specialised education is by no means limited to those opportunities available within the industry and, in fact, the net has been cast very widely indeed through the foresight of manufacturers in making installations available to educational authorities and thus providing a flow of well-informed students to both manufacturers and users.

Conclusions

In summary the general impressions gained were that the use of computers for commercial and industrial data processing was far more widespread in the USA than in this country, particularly amongst the smaller business units, for which there are, no doubt, very sound economic reasons which may not be applicable in this country as yet, but which are, perhaps, not far off. There was certainly a far greater investment in research and development in all aspects of computer work, whether it be in technical electronics, in applications, communications or general education; in fact, this investment seemed to be proportionally greater by any standard, whether it be per head of population or business turnover. In so far as integration may be the goal, this has not yet been achieved, though substantial and encouraging progress has been made. In this respect I do not call to mind any user who was not looking expectantly to the future but, at the same time, had not already been encouraged by the results achieved so far. None of this is really new or unexpected, but there was one predominant conclusion to be drawn from everything that was seen—that electronic data processing is here to stay. Not because it is too difficult to go back, but because it will pay its way, even though the lead time necessary may prove to be longer than was expected at one time.

Acknowledgements

It would be quite remiss to make no mention of the most outstanding memory of all. The welcome given to members of the mission by users was outstanding in every respect and the time and attention devoted to our inquiries, which could only have been inconvenient, could not have been given more generously. These facts, coupled with the traditional hospitality of the Americans, which is in no degree less than its reputation, leave a personal impression that will not easily be removed. It should also be mentioned that the degree of mutual understanding, co-operation and friendship developed between the individuals, representing many different European countries, taking part in this mission was outstanding. While this unquestionably developed through spontaneous goodwill and mutual interest it was undoubtedly assisted by the good leadership from our Chairman and officials.

The official report of the mission is (to be) published by the European Productivity Agency under the title *IDP and Computers*, November 1960. (*H.M. Stationery Office*.)

DISCUSSION GROUPS

The following notes describe some of the activities of a particular Discussion Group. This is Group No. 4—Operational Experience which is starting on a well planned series for the winter session continuing from the meetings arranged last year.

Representatives of companies who have had a computer installation for some time have been invited by the members of this group to discuss experiences in operating data processing systems. The following meetings have, so far, been arranged:

Date of Meeting	*Type of Computer*	*Name of User Company*	*Type of Application*
8.11.60	1201	General Post Office, Supplies Dept., London.	Stores Control and Stock Provisioning.
7.2.61	LEO II	Imperial Tobacco Co. Ltd., W. D. & H. O. Wills Branch, Bristol.	Sales Accounting, Invoicing and Statistics.
7.3.61	PCC	Hoffmann Manufacturing Co. Ltd., Chelmsford, Essex.	Sales Accounting.

Members of this group will be separately notified of these and later meetings. Mr. F. C. H. Witchell, who as Chairman of the group, has done so much to make it successful and has arranged the meetings described above is now obliged to resign the chair due to pressure of work.

Any member of the Society who wish to join a discussion group or suggest a subject for a new group should write to Mr. P. V. Ellis, Chairman of the Study Group Committee.

COMPUTER COURSES FOR COLLEGES

by M. M. Barritt

This article is based on a paper given at a Conference on the Computing Laboratory in the Technical College at Hatfield Technical College on 27–28 May 1960.

Many technical colleges are contemplating the installation of a digital computer so that it would be useful to discuss some problems which appear to be indigenous to a technical college, but do not necessarily occur in a university laboratory or industrial computing unit. These views arise from experience gained in departmental courses and part-time lecturing in technical colleges. In the RAE Mathematical Services department we had delivery of our first DEUCE in 1956, the second in 1957, and MERCURY in 1959; in this period we have organised Computer and Numerical Methods Courses for some 400 people. Whether based on the department or the RAE Technical College they have always had a high content of practical work. Computing has a strong affinity to cooking, practice can be so very different from theory—and in program testing there are so many variables.

Possession of a computer presupposes use of a computer which poses the first question—"What purpose is the computer to serve?" The answer defines the pernicious crime of "Wasting Computer Time" and should be a guide to "The organisation of the computer laboratory and courses." Computer time is a very precious commodity. It is usual for a machine to be switched on until at least 10 p.m. and often through the night and at week-ends. The time until 6 p.m. is very often apportioned as in the table below.

Table 1—Computer Day

(1) Routine maintenance.
(2) Program testing (say 10 mins./person/day).
(3) Production (say ½ hour/person/day).
(4) Training of operators.
(5) Training of maintenance staff.

The very keen users and slow program testers often slip in for extra time at off-peak periods. The later shifts are usually allocated to long production runs and additional overhauls. The majority of computer units combine "Open Shop" and "Operator Service" running to gain maximum efficiency for their requirements.

How will schemes of this kind suit the technical college? To reach any conclusions we shall have to classify the student users, college staff and prospective buyers of machine time. They will conform to Table 2.

Table 2—Categories of Students

(1) Commercial background.
(2) Scientists.
(3) Electronic engineers (prospective development and maintenance staff).
(4) Mathematicians:
  (i) General.
  (ii) Numerical analysts.
  (iii) Statisticians.
(5) Programmers.
(6) Operators.

We further compare the technical college with the university student in three important aspects.

Table 3

	Technical College	*University*
Access	Usually part-time, may live up to 100 miles away.	Usually full-time, resident.
Availability	Rigid crowded time-table.	Flexible uncrowded time-table.
Attitude	May use bigger and better computer.	Unlikely to use any other computer.
	May be nominated by employer.	Volunteer.

Clearly we must modify the usual schemes to suit the technical college environment. *Access and availability* will undoubtedly produce a bottle-neck in college for the evening; only a small amount of time will be available for practical computer work. He will not be able to use the college equipment in his "spare time" if he lives a long way away, and obviously he may not have access elsewhere. Thus the practical work will have to be highly organised; some form of operator service would seem to be essential if progress to "real" programming is to be achieved. On the other hand, learning to *operate* and *master* the computer and ancillary equipment should be an integral part of any course.

The solution for categories (1) and (2) would seem to be a good operator service, combined with specific training in operation of all equipment.

Attitude

This I feel is the crux of the matter. There are some very complex psychological forces surrounding "The Computer," the attitude of the man in possession being akin to a car driver. The normally polite and considerate become boorish and unreasonable in the guise of program testers. If they ever reach the production stage they may get correspondingly worse, and often completely disorganised.

A sense of humour, tolerance and patience, combined with firmness is therefore essential in all staff directly associated with the running of any computer.

All these symptoms will be aggravated in the case of the technical college student placed on an unsuitable course. Even if he is used to more time on a bigger and better machine he will be co-operative *if introduced to the college machine in the manner appropriate to his category.*

Training Schemes

A college may be expected to cover the following topics.

(1) Coding for the college computer—use of basic machine code and autocodes.
(2) Operation of the computer and ancillary equipment.
(3) Numerical methods.
(4) Desk machine test cases.

(5) Logical design.
(6) Other types of computer and peripheral equipment. Sources of automatically recorded data.
(7) Applications of computers to automation, data processing and business control.
(8) Maintenance, development and design of college computer.

I have deliberately omitted statistics; practising statisticians must use numerical methods, but programmers do not have to know statistics although this may well be desirable.

Congenial Courses for Technical College Categories

In most cases the objective is for the student to see the computer as a *tool*, not as an end in itself. Until he has facility he will regard the machine as an *obstacle*, to many a part-time student who has already programmed bigger and better machines an *unnecessary obstacle*. The secret of success lies in the presentation of the order code and in an efficient operator service. Let us now go through the classification with recommendations (see Table 2).

(1) Students from commerce benefit from the lavish use of flow-charts. Example, based on autocode, need to be in the language of commerce.

(2) A concentrated autocode course and limited operator training, e.g. a three-day residential school is suitable for scientists. Immediate application to formulae drawn from their own work is helpful. A basic training in numerical methods must be given and examples demonstrated in autocode with the help of a computer operator. Full use must be made of the machine library.

(3) Basic machine code, autocode and carefully chosen examples are required for the electronic engineer. A concentrated course is not essential.

(4) (i) *General Mathematicians and Statisticians*
The approach is similar to that for scientists, but the basic machine code on suitable examples can be used. The manufacturer's manual is not often followed in sequence. Full use must be made of the library and operator services.

(ii) *Numerical Analysts*
Examples in numerical analysis theory should be programmed *currently*. All coding classes are subservient to this end. This may entail an initial high ratio on the time-table of Computer Training to Numerical Analysis theory. Desk machines can be used for test cases. When the course has settled down to an integrated whole the finer points of programming and machine operation can be introduced in classes in their own right. It may be desirable to do some "simulator" work showing the effect on methods of larger and faster computers. The operator service should be used to keep the programming pace up with the theory of computing methods. Some group activity may save computer time, e.g. make one subroutine each to learn the nature of large-scale programming problems.

(5) Can safely work through manufacturer's manual; as much machine operation as possible.

(6) Machine code and autocode examples on interpretation of machine behaviour in program testing.

Conclusions

It is impossible to carry out this ambitious scheme wholly on a spare-time basis. A high standard of machine knowledge, backed by practical experience, is required in more than one member. The universities undertake large-scale research projects which give their staff opportunities for experience. What are the plans for the technical colleges? Unless positive arrangements are made their knowledge may even be inferior to the students' which seems unfair to all. What will be the provision of laboratory staff for the operating service? Will the laboratory be used in the vacations for short "schools"?

In the writer's experience the success of any computer venture is measured mentally in "turn-round time," so that programs which continually fail to reach the production stage do harm to the new student. Too much help is wrong, but so is too little. In a class of twenty students for two hours a week it is very hard for one lecturer to give adequate instruction unless he has the help of one or more demonstrators.

CORRESPONDENCE

Letters from readers are welcomed, and should be addressed to the Editor, The Computer Bulletin, Finsbury Court, Finsbury Pavement, London, E.C.2. The name and address of the writer must be given, but will not be published if requested.

Review Comment

Sir,

Having just received my copy of the March 1960 issue of your interesting *Bulletin*, I noted with interest the review of my book. The reviewer's kind comments are appreciated.

However, I do not understand the remark that "references are limited to American publications." I note that seven books of British origin and two other non-American books are referred to in my book. As one who enjoyed the First Annual National Conference of your Society at Cambridge in the summer of 1959, I assure you that I have no intent to neglect the British work on computers.

Yours, etc.,
E. M. McCormick

8720 *Ewing Drive*,
Bethesda 14, *Maryland*, *USA*.

**

BITTEBITTEHAHA

by William Phillips, F.I.A.

As a contribution towards the history of electronic calculating and data processing, should one ever be written, when the idea of an electronic computer was first put forward, in January, 1936, the use was advocated of the binary scale of notation, which contains only the digits 1 and 0, capable of being represented in the ordinary thermionic "flip-flop" valve by means of its two only possible "states,"* or on paper tape by "hole" or "no hole."† But it is to be observed that at the same time that the binary scale was advocated for all processing within the computer, whenever one should be constructed,‡ it was proposed that the octonary scale (powers of 8, using only the digits 0 to 7) be used for all records.

Let others write the history; the writer's present purpose is to save his fellow countrymen from what may be called "bimbamism," an insidious disease which, it seems, is threatening to sweep across the North American Continent. All the history we need to understand this disease, and to note with astonishment and horror that it should ever have appeared, and to sound a warning against the failure—which has occurred in so many other directions in the history of so many new developments—the failure to take the trouble to turn back to what was said in the early pioneering days, and to profit from it, can be stated in a very few words.

During the war, when already those plans for the construction of an electronic computer working in scale of notation 2 were being made in this country, which eventually crystallised as the ACE computer of our National Physical Laboratory, our American cousins constructed for war purposes more than one electronic computer working in the scale of ten. This is not criticised, for there was a very good reason for it; expense was no object, urgency was the overriding consideration, and there was ready to hand a plentiful supply of automatic telephone-dialling components, available for use in, and in fact used in, the earliest electronic computers completed and put to work.

But even before the war ended the Americans were aware of the plans being made here, and there has been no computer ever constructed for commercial use, on either side of the Atlantic, which has not employed the binary scale in some form or other.

A Rash of Ones and Ohs

It is therefore as pertinent to remark now, as it was 25 years ago (with "s.n." as an abbreviation for "scale of notation") that

> the recording and compilation of figures in s.n. 2 would be exasperating and a source of much error. Seven significant figures in s.n. 10 may require as many as twenty-three in s.n. 2, and anyone who has had the least practical experience can visualise the danger of transposition and other integral errors in compiling and dealing with line after line of figures, as many as twenty-three to the line, consisting only of units and cyphers.

* Or now the transistor.

† Or on metal tape by a magnetised spot or its absence; and very recently by encapsulated liquid cells coloured blue or colourless of which one million occupy one square inch.

‡ And of course the author was told that none ever would be constructed, that there was absolutely no need for it; and narrowly missed being executed in the Tower of London for advocating the use of binary arithmetic!

The method of resolving this difficulty put forward in 1936 lies in the ready conversion from s.n. 2 to s.n. 8, and from s.n. 8 to s.n. 2. To take one example, the current year, customarily represented in s.n. 10 by the sequence of digits 1960, which by an agreed convention we understand as meaning 10 cubed plus 9 times 10 squared plus 6 times 10 plus 0*, is 11110101000 in s.n. 2, and in s.n. 8 is 3,650; and if we mark off the "rash" of 1's and 0's in groups of three thus: 11,110,101,000, we can read it at sight as 3,650, once the following table has been committed to memory:

s.n. 8	s.n. 2
1	001
2	010
3	011
4	100
5	101
6	110
7	111

Indeed, "committed to memory" is too grandiloquent a phrase to apply to so simple a matter, for our units are $1 = 001$, $2 = 010$, and $4 = 100$, and the rest follow by adding the appropriate units together, no other calculation being quite so onerous as $7 = 4 + 2 + 1$, and even that should not prove too onerous for a five-year-old child. All of this, be it remembered, was propounded nearly 25 years ago; and in passing the writer cannot refrain from saying that he is astounded, and disappointed, that the repeated conversion of figures back and forth between s.n. 10 and s.n. 2, at the great cost in time and money of doing this repeated operation inside the computer, in order to perpetuate the widespread recording in s.n. 10 of figures which are not needed outside one's own business until the annual balance sheet and accounts are made up, and which could so much better be in s.n. 8 for the other three hundred and sixty odd days of the year, should have persisted so extensively.

Bimbamism

For the present, however, we are concerned only with how to "read" computer output which takes the form of a string of 1's and 0's. Soon after the war ended, and the first commercial electronic computer in this country was in daily use, there was attached to it a counter which recorded the number of cycles operated by the machine. Its visible part consisted of a row of miniature electric light bulbs, the one on the extreme right representing a unit when lighted, the next representing 2, the next 4, and so on, any bulb not lit representing 0—a perfect example of the binary scale not only working but working visibly. Two things about this counter impressed the present writer very forcibly. The first was that at the very instant that the computer commenced to function *the five or six right-hand-side bulbs lit up simultaneously*, as it seemed, and seemingly remained lit up so long as the computer continued to operate. But why not? What actually happened, of course, was that bulb one lit, then

* The 0 which gives the other three digits their positional value, one of the world's most wonderful inventions, for want of which arithmetic languished for 1,500 years.

went out as bulb two lit, then one lit again, then one and two doused as number three lit up, and so on, so much too quickly for the reaction of the human eye to "see" anything of these first five or six bulbs but a steady light from each of them. That by the way; the second point which impressed the writer (and that sadly) was that the bulbs were not marked off in groups of three, so enabling them to be "read" in s.n. 8. Now more than another decade has passed, and in a recent issue of the American periodical *Science* a writer, who shall in mercy remain anonymous, has written:

> While I am on the subject of reform, having been a binarist from the word *bit*, let me suggest a simple method of saying the binary numbers.

Pausing there for a moment, what he means is that he has been convinced of the advantages of binary calculation for about one-half of the period which has elapsed since it was first advocated for electronic computers, say twelve or thirteen years, as compared with over 250 years which have elapsed since Leibniz interested himself in binary arithmetic, and the more than 2,000 years since our ancestors knew no other arithmetic than the binary—perpetuated in our florin, shilling and sixpenny piece, and our penny, half-penny and farthing, and in fractions used for measurements of length, and still partially surviving in our 4 gills 1 pint, 2 pints 1 quart, 4 quarts 1 gallon, with traces elsewhere, as in 8 drachms to the ounce, 16 ozs. to the pound, and 8 furlongs to the mile. The writer in *Science* continues:

> I say "saying" rather than "naming" because I do not really approve of naming numbers anyway. . . . Even in the decimal system it seems to me foolish to *name* the perfectly good number one-nine-six-oh . . . under the laborious title "one thousand nine hundred and sixty." Attempts to *name* the binary numbers end up in hopeless clumsiness and cacophony. On the other hand it is perfectly easy to *say* the binary numbers if we adopt one conventional symbol for "1" and another for "0." I have toyed with "Bim" for 1 and "Bam" for 0, in which case we would count: Bim, Bimbam, Bimbim, Bimbambam, Bimbambim, Bimbimbam, Bimbimbim, Bimbambambam, and so on.

In case the reader has lost count, the first seven of these cacophonies correspond to the seven lines of the table set out above, while Bimbambambam means 1,000 in s.n. 2, or 10 in s.n. 8, namely eight, and one would not have thought that it was easier to say "bimbambambam" than to say "eight," and have done with it.

Bitteism

But worse follows when the convinced binarist gets into larger figures, the only ones with which the user of an electronic computer is likely to have any trouble:

> If this [bimbamism] sounds too sonorous [he writes] I am prepared to compromise on "Bit" (for 1) and "te" (for 0), in which case we count Bit, Bitte, Bitbit, Bittete, Bittebit, Bitbitte, Bitbitbit, Bittetete, and so on. I may point out that (to look a few years ahead) Bitbitbitbittebittebitbitbitbit has no more syllables in it than "one thousand nine hundred and sixty-seven."

No, but it has six more syllables than the five required by the 1936 recommendation that 11,110,101,111 be "read" as "three six five seven." If all this bittebimbam nonsense had been put forward in some burlesque magazine one might have regarded it as a not unamusing parody of the late arrivals who have attempted to purchase tickets entitling them to jump on the electronic band-waggon by inventing an exotic vocabulary containing such words as "bit," "hardware" and "half-adder," without which, in their ignorance, those earlier on the scene thought they got along very well for the first twelve years or so. But no, this is (presumably) an entirely serious suggestion, put forward in an entirely serious periodical, and it is much to be hoped that in this country it will be recognised that this is a wabe in which we shall all do well not to gyre and gimble. In the famous words (almost) of Lewis Carroll:

> Beware the Bimbam bird, and shun
> The frumious Bittebit.

The author of the 1936 paper has put it on record that he deferred the advocacy of electronic computers for some time, because of this very want of a ready means of "saying," and still more important, of recording, numbers expressed in the binary scale of notation which he intended to recommend, and was somewhat ashamed of himself for having taken a year or two to realise that both could be done, at sight, in the octonary scale. Perhaps he need not have been so very much ashamed, after all, since one person at least, and that a convinced binarist, and his editor, have still not realised it, nor taken the trouble to observe that this expedient, so obvious and so simple once it is hit upon, was put on record a quarter of a century ago.

Ericsson and Bendix form Joint Company

An agreement in principle has been reached between *Ericsson Telephones Limited* and the *Bendix Corporation* of the United States, to form a jointly-owned company to manufacture and market a wide range of high-precision instruments and electronic devices, principally for industrial and scientific requirements.

The new company, *Bendix Ericsson UK Limited*, will be located in Nottingham and will acquire the instrument division of *Ericsson Telephones Limited*, to serve as a nucleus for future activities. The aim is to expand the output of existing products, to develop new products of an advanced nature, and to manufacture additional products under licence from the parent companies.

The new affiliation is not expected to disturb existing licensing arrangements, of which Bendix have many in the United Kingdom. Dr. J. H. Mitchell, Research Director of *Ericsson Telephones Limited*, will be the Managing Director of the new Company.

COMPUTER COURSES 1961

The Editor has received details of courses in Educational Institutes additional to those published in the previous issue. Details of other 1961 courses will be published in the next issue of the *Bulletin* if the information reaches the Editor by 15 January 1961.

Courses

Courses	*At*	*Commencing*	*Fee* £ s. d.	*Lectures*	*Times*
Introductory Computer Mathematics	Glamorgan College	11 January	10 0	13 weekly lectures	6.15–8.15 p.m.
Computers for Industry and Commerce	Leicester College	23 January		8 weekly lectures	6.45–8.15 p.m.
Simple Code for STANTEC–ZEBRA	Leicester College	17 January	1 10 0	10 weekly lectures	6.30–8.30 p.m.
Analogue Computers	Leicester College	18 January	1 10 0	10 weekly lectures	6.30–8.30 p.m.
Mercury Autocode	London University	2 January (Repeated 20 March and 5 June)		Full-time (2–6 January)	
Advanced Mercury Programming	London University	16 January		Full-time (16–25 January)	
The Orion Computer System	Northampton C.A.T., London	4 January	2 2 0	12 weekly lectures	6.30–8.00 p.m.
Programming KDF 9	Northampton C.A.T., London	16 January	1 1 0	5 weekly lectures	6.30–8.00 p.m.
KDP 10 Data Processing System (Application and Programming)	Northampton C.A.T., London	17 January	2 2 0	10 weekly lectures	6.30–8.00 p.m.
Circuits of Digital Computers	Northampton C.A.T., London	17 January	2 2 0	10 weekly lectures	6.30–8.00 p.m.
Simple Code for STANTEC–ZEBRA	Woolwich Polytechnic	22 February		6 weekly lectures	7.00–9.00 p.m.
Advanced Numerical Methods	Woolwich Polytechnic	9 January		12 weekly lectures	6.30–8.30 p.m.

* * * *

Computer Manufacturers

It has not proved possible to summarise the variety of courses offered. Much helpful literature is available and it is suggested that interested readers write to:

AEI Ltd.	K. C. Evans, Electronics Apparatus Division, Trafford Park, Manchester 17.
Bulmers (Calculators) Ltd.	A. R. Rider, 47–51 Worship Street, London, E.C.2.
Elliott Bros. (London) Ltd.	F. S. Ellis, Elstree Way, Borehamwood, Herts.
EMI Electronics Ltd.	J. W. Godfrey, Computer Division, Hayes, Middlesex.
English Electric Co. Ltd.	J. Boothroyd, Data Processing and Control Systems Division, Kidsgrove, Stoke-on-Trent, Staffs.
Ferranti, Ltd.	R. Wilkinson, 21 Portland Place, London, W.1.
IBM United Kingdom Ltd.	The Education Department, 101 Wigmore Street, London, W.1.
ICT Ltd.	F. A. Worsfold, Bradenham Manor, nr. High Wycombe, Bucks.
Leo Computers Ltd.	R. P. Gibson, Hartree House, 151A–159A Queensway, London, W.2.
National Cash Register Co. Ltd.	D. H. Triggs, 206–216 Marylebone Road, London, N.W.1.
Standard Telephones and Cables Ltd.	F. G. Filby Information Processing Division, Corporation Road, Newport, Mon.

DISCUSSION MEETING: PART I

CHARACTERISTICS OF COMPUTERS OF THE SECOND DECADE

Reported by
Dudley Hooper

Well over 400 members and guests of the Society attended a full day's discussion meeting at Northampton College on 22 September 1960. Dr. F. Yates (Chairman of Council) presided, and expressed the Society's thanks to Miss Kilner and the British Transport Commission for permitting her paper to be circulated and used as a basis for discussion, and to the eight manufacturers who would later be represented on the platform for participating in what had been agreed would be a useful discussion rather than a sales platform.

* * *

Introducing Miss Kilner's paper, Mr. G. H. Hinds (British Transport Commission) explained that it had been prepared for the Commission during a continuing survey of available computers. During this survey it became apparent that during the last eighteen months many new computers were being announced or making their appearance, and that these all have characteristics which are an advance on those to which we have become accustomed. It was therefore decided to make a critical review of the novelties. When this work was well under way, a start was being made on the plans for the Society's discussion meeting, so that it seems sensible to use the one paper for the two purposes. He stressed that neither the British Transport Commission nor The British Computer Society Limited accept any responsibility for the facts or opinions stated in the paper, but every effort has been made by the author to check the information with the manufacturers.

One difficulty encountered in preparing the paper has been to reconcile the jargons of various firms, and to present the information in a common language; the collaboration of manufacturers in this respect is gratefully acknowledged.

* * *

Mr. Hinds continued: "Nearly all the novelties in the new machine are designed to increase the amount of work that can be done in a day without a proportional increase in the cost. Chief among these is the facility for 'concurrent operating,' which was envisaged in the Presidential Address to the Society two years ago. In machines of the first generation, instructions were obeyed sequentially; as the number of organs engaged in carrying out any one instruction is strictly limited and as some of these organs are very much slower than the arithmetic and logic units, the greater part of the machine was idle for the greater part of the time. With concurrent operating systems, the control unit or units initiate the simultaneous execution of a number of instructions or groups of instruction in parallel; in the simpler systems this makes possible simultaneous work on several branches of the same program and, in more sophisticated systems, simultaneous work on several programs, this being effected either by built-in circuitry or by programming.

"In addition to the great increase in over-all speed brought about by concurrent operating, a number of other consequential trends are appearing; the necessity for the off-line operation of slow peripheral units is disappearing; so too is the need for buffer stores; the external interrogation of data in the computer store is possible without materially delaying other programs; where a number of programs are running simultaneously, one may be a test program so that the correct functioning of the whole machine may be under continuous surveillance; or may be a diagnostic program automatically called in by the failure of a parity or other internal check. The possibilities appear endless.

"Variable word length is a feature which, although not new, is becoming more used; about half of the data processing systems reviewed (as distinct from scientific machines) are so designed. As applied to instructions this leads to a more flexible order code, which may in some cases include single character (no address) instructions, and others with one, two, or even three addresses: as applied to data, and more particularly to commercial items, it saves in storage space and transfer time. In some systems the word length contains a variable number of individual decimal or alphabetic characters, and in others of units, each of a small number of characters.

"Most of the other noteworthy features are extensions of devices already used in simple form or in smaller numbers. For instance, the number of Index or Modifier Registers provided sometimes exceeds one hundred; floating point and multiple-length arithmetic are now common-place in scientific computers; the number of magnetic tape units under the control of one computer has greatly increased; at least two machines work automatically in mixed radices (decimal, sterling, weights, etc.); and there is a big extension of the use of permanently-stored subroutines, and of error-detection (and one or two examples of error-correction).

"Engineering advances of course include a reduction in size, weight, and power consumption due to the almost universal use of solid-state devices instead of valves, and a big increase in the speed of input readers and output printers.

"May we as users hope for a corresponding increase in overall reliability?"

THE CHARACTERISTICS OF COMPUTERS OF THE SECOND DECADE

A REVIEW

by Miss D. E. Kilner

This shortened version of Miss Kilner's paper omits references to specific machines in the narrative. The characteristics described in the paper are, however, summarised against each machine in the author's tables, reproduced on pp. 98–112.

INTRODUCTION

Object of the Paper

Much has been published recently surveying the first ten years of computer development and anticipating developments during the second decade. This natural break in time has given rise to the terms first generation and second generation computers. It is surely difficult for someone, say, a business man, outside the circle of those concerned with the actual design of computers, to find his way among the mass of new, diverse equipment now being offered under the umbrella title of second generation computers. Through discussions with manufacturers or talks at learned societies he may acquire knowledge of individual machines, but he is then still not in a position to make the necessary comparisons, nor to acquaint himself with trends in computer design, a position which he must hold before he can make a choice from among these machines. He very often has not the time nor the staff to undertake such studies. Indeed, computers are still such a comparatively new force in his world that he may even feel that the first generation is sufficiently mysterious without embarking on a study of the second. But there have been within the past year or thereabouts so many announcements of new designs that, in the endeavour to equip himself to make an effective choice of a computer for his purpose, it is essential that he has a grasp of the whole computer situation. This paper is believed to be the first attempt to make such a study of second generation computers and its object is to assist someone in this position to understand these latest developments in the computer field.

Scope of the Paper

Discussion is confined to the features of computers available for purchase in the U.K. and to those on which information is available. The following are covered in the main paper and/or the Tables which follow:

High Speed Scientific Computers and Data Processing Systems

ATLAS
IBM 7030 (STRETCH type computer)

High Speed Scientific Computers

IBM 7090
ELLIOTT 502 (designed specifically for real-time working)
ELLIOTT 503
ENGLISH ELECTRIC KDF9

Data Processing Systems with one Control Unit

(i) *with automatic time-sharing features*

AEI 1010
ORION
LEO III
IBM 7070
IBM 7080
EMIDEC 2400
NCR 315
KDP 10
ICT 1301

(ii) *without automatic time-sharing features*

EMIDEC 1100
STANTEC Computing System
IBM 1401

Data Processing System with more than one Control Unit

GAMMA 60

Smaller Systems announced from 1959 onwards

(i) *with automatic time-sharing features*

NATIONAL-ELLIOTT 802/803

(ii) *without automatic time-sharing features*

BULL 300 DP Series
IBM 1620

All are general-purpose computers: no special purpose computers (i.e. those with a fixed program as against those which can take a variety of programs) are considered, although the future for these is probably considerable and many manufacturers are building up a range of units from which they could be constructed.

No general description is given of the way a computer works. The broad outlines and outstanding features of the designs are discussed, but not the details. In particular discussion is of features through which these computers are in advance of computers of the first decade.

Every attempt has been made to check this information by consultation with the manufacturers and acknowledgement is gratefully made to them.

Perhaps it would also be as well to disclaim in advance any direct attempt to evaluate the relative merits of these computers in use: the study is merely of their characteristics which should be made clearer by comparison. These characteristics are set out in four Tables on pages 98 to 112.

DEVELOPMENT OF DIGITAL COMPUTERS IN THE FIRST DECADE, 1949–1959

To place computers of the second decade in their right perspective, it is necessary to see how these machines have developed so far. Relay computers soon lost the race to

electronic machines and the faster speeds which these brought in their train almost necessitated the development of the stored program to enable efficient use to be made of them. Many storage techniques have been tried and eventually superseded by others for their greater speeds of access, their greater flexibility in working or the larger capacity they offer, until now the high-speed or working store is almost universally a magnetic core store of the random access type, with magnetic tape as the large capacity file store and magnetic drums or discs for the medium-access backing store, if such a store is provided at all. Two, or more usually three, level storage is universal now for all computers. In general, the cost of the store goes up as its access time decreases and, for a fixed cost, the size of the store decreases for faster access time, and hence it has been found that flexibility and economy together are obtainable only by providing slow, medium and fast access storage in the proportions required. The input/output media used to date have been punched paper tape, punched cards and magnetic tape, that is, media (especially in the first two cases) already well established in this or other fields. Demands for increased speed and also for greater reliability in operation have led to the introduction of solid-state components for switching and storage, with the gradual replacement of vacuum tubes and earlier physical forms of store, and also to the improvement of production techniques, the use of printed circuits and of standard packaged units in construction, for example. Increased speed has also been sought through multiplying the amount of simultaneous operation within the computer, by overlapping the input, output and computing operations, as well as by increased speeds in the peripheral units themselves, and increased reliability through the use of error-detecting codes and built-in checking devices, although there has been wide diversity of opinion as to the value of the latter.

With the application of computers to business problems, which did not really begin until 1954, it became evident that the philosophy behind the early designs used for scientific computation was no longer valid for the design of business machines. This follows from the fact that much of the processing of data required from a business computer is not mathematical at all, but simply a mechanised clerical function, and there has grown up a certain distinction between computers designed for each purpose. The main difference has been the relation between the amount of input/output data and the amount of computation required; in business applications a small amount of actual computation is necessary for a large volume of data, but in scientific applications the reverse is generally true. This has led to a much greater interest in all forms of ancillary equipment and to the development of computer design based on a building block principle in which there is provision for a large number of optional peripheral units surrounding the central working units, with flexibility obtained by choosing these units to suit a particular application.

This development served to highlight the problem of unbalance between the electronic speeds of the computer and the mechanical speeds of the peripheral units, with the consequent loss of overall speed of operation. One solution to this problem was, as has already been mentioned, to try to overlap the input and output operations with the actual computing and other methods of overcoming this lack of balance were tried. Buffer stores were introduced between units of different speeds, both between peripheral units and the store, and between different levels of storage. Many data processing operations were relegated to off-line working, thus not affecting the speed of the computer. The disadvantage of both these techniques is the additional cost involved through the provision of extra units, off-line units in particular becoming almost like special-purpose computers in themselves.

The different types of problem so far tackled with the aid of a computer can be grouped in many ways and here are grouped under five headings: (i) Scientific and Mathematical calculation, (ii) Engineering and Technical, (iii) Commercial, (iv) Operational Research, and (v) Non-numerical. The important point is that hitherto computers have played a supporting role in nearly all applications; they have not yet really been used as the hub of an organisational problem, for fully integrated data processing, as this concept has come to be called. In fact, many of them are still doing exactly the same jobs that have hitherto been done by older tools, punched cards, for instance, with little attempt to exploit their full potentialities. New tools bring new possibilities in their train and it has become a commonplace now to say that a high-speed digital computer can be used in the solution of problems which previously just could not be faced, owing to either prohibitive cost or to the amount of time and labour involved. Probably nowhere is this shown more clearly than in the field of Operational Research, where the development of mathematical techniques received impetus from the development of computers capable of handling them. But it is still true to say that computers are only just being envisaged in the role of the corner-stone of the work in which they are employed.

Even a cursory glance at the development of computers cannot be taken without some reference to the relation between this development and their eventual cost. The use of two- and three-level storage systems has already been shown to be governed by the cost of the different types of store. The development of packaged units, the employment of mass-produced elements, the reduction in size, weight and power following from the use of solid-state components, the increase in reliability and consequent reduction in maintenance, all these things have been pursued with an eye to the eventual reduction in price of the computer and this cost factor, the amount that customers are prepared to pay for equipment, will continue to influence its future development.

DISTINGUISHING FEATURES OF COMPUTERS OF THE SECOND DECADE

It could be argued that most of the features characterising computers of the second decade, or at any rate the data processing systems of this decade, have sprung from a maturer conception of their potentialities. As the building block principle behind computer design arose out of the desire to apply these machines to business problems, so the distinguishing features of second generation machines have grown out of this change in their status from that of a supporting function to that of having the primary role in the system and to, moreover, very nearly real-time work.

This new conception of the role of the computer necessitated even higher operating speeds and those of the computers under discussion in this paper are of the order of one thousand times faster, as far as internal operating speeds are concerned, than those of the first decade. Whereas basic computing speeds used to be measured in milliseconds and microseconds, these now tend to be expressed in microseconds and millimicroseconds. But the overall increase of speed is not only due to the use of components of increased speed, but is also due to the development of all forms of

concurrent operating within the computer system. This term is used in this paper to cover a whole range of techniques from the overlapping of the carrying out of individual instructions to the running in parallel of two or more series of instructions, either from one program or from entirely different programs, through the time-sharing of one control unit or through the provision of more than one control unit.

This new development demands also facilities for interrupting the running of the computer with a program of higher priority, particularly in process control or real-time work. In their turn these concurrent operating techniques lead to a new conception of the use of peripheral units. Since their slower operation will no longer hold up the working of the whole system there is no longer the same need to relegate their use, as far as possible, to off-line working, nor to limit their number. Neither is there the same need to provide buffer stores of any size. Finally, this more intricate computer operation leads to renewed demands for even higher reliability and safeguards in operation, for are not faults of all kinds going to be far more difficult to diagnose and correct in these vastly more complicated operating situations?

The other aspects of these new computers described here could be classed as unresolved conflicts of opinion among designers, conflicts left over from the first decade, or extensions of previous developments. There are extensions of the building block principle even to providing a variable number of working storage units to customer's requirements (see Table III): there are new types of store, including the use of fixed stores, as well as the retention of random access file units: there are still great variations in the address systems in use and developments in the provision of arithmetic and B-register facilities; there are very significant changes in the construction of the word length.

These facets of computer design will be treated in the next sections which should be read in conjunction with the four Tables of Comparison.

CONCURRENT OPERATING TECHNIQUES

General

In the same way that the stored program was a development in the history of computers which enabled efficient use to be made of the fast electronic arithmetic unit, so concurrent operating techniques will enable the maximum advantage to be gained from the ultra-fast operating speeds now available in computers using more advanced components. The philosophy is that the computer and its peripheral units should never be idle: that time which it might otherwise have spent waiting for, say, a peripheral device to complete its operation, should be used to perform some other branch of the program or, latterly, even some part of a totally different program. Thus the problem of the loss of efficiency through the lack of balance between slow and fast units has to a considerable extent been resolved.

These techniques are various and the terms used to describe them call for definition within the context of this paper. As has been said, many first generation computers allow for more than one operation at a time; peripheral units may operate simultaneously with the execution of the next non-conflicting instruction by the control unit, thus avoiding the delay which might entail if the computer had to wait for a long operation to be completed in one part of the machine. This is a common feature of many present-day computers: indeed, in some it has reached an advanced state. Nevertheless, they are still essentially the type of machine which proceeds by carrying out a sequence of operations, each specified by *one instruction* from one control unit at a time. This technique, simple or advanced, has now been called by the definitive term, *simultaneous operation of units*.

Parallel programming has been defined (*Gill*, 1958) as the control of two or more operations which are executed virtually simultaneously, and each of which entails following a *series of instructions*. This can be brought about in a single computer either by equipping it with more than one control unit, or by allowing time-sharing of one control unit between several activities. This has led to the development of techniques for interrupting one series of instructions to deal with another of higher priority. It is, of course, obvious that parallel programming results in and includes the feature of simultaneous operation of units.

The next step in complexity is taken when more than one program is stored and dealt with at a time. This can be arranged by using, again, either of the methods specified above.

Some of the problems which have to be taken care of in the design of a computer with parallel programming may be set out as follows:

(*a*) The computer must not try to initiate a further operation in a unit before the previous one has been completed.
(*b*) There must be no possibility of one program overwriting another in the store, or interfering in any way.
(*c*) Provision must be made to ensure that, where simultaneous branches of a program are being followed, control proceeds to the next part of the program only when all the branches are finished and have been re-combined.
(*d*) During time-sharing operations provision must be made for storing away the contents of registers and accumulators during program interruption and for restoring these when the main program is restored.
(*e*) Some means of determining priorities for the switching of the control unit are essential.

Methods of Organising the Time-sharing System of One Control Unit

In a system involving the time-sharing of one Control Unit, there are fundamentally two basic techniques used in the interruption of one series of instructions to deal with another:

(*a*) by an interrogating or *scanning* technique, the control unit switching according to the state of the units interrogated or scanned, and/or,
(*b*) by a *break-in* technique where signals are sent from other units of the system, or from external sources such as manually from the console or from an interrogating keyboard, to the control unit which then transfers control according to the signals received.

The words *scanning* and *break-in* have been used advisedly because of the confusion to which the use of the word *interrupt* gives rise. In either technique it is clear that the program is interrupted, therefore it seems better to reserve the word *interruption* for that general use and to use the term *break-in* to signify those occasions when a signal from a peripheral unit seizes control of the Control Unit.

As is shown in Table II most machines use basically either

one technique or the other, but occasionally, a combination of both. In the latter technique the moment in time when an order is obeyed is chosen not by the control unit, but by the peripheral unit, and there would seem to be greater saving of computer time in the adoption of this principle rather than of the former in which time, however small, has to be spent in scanning to find the peripheral unit requiring attention.

It is evident that there has always been interruption of programs through parity failures and other forms of detecting error. Formerly these eventualities would have stopped the machine (although only after repeated attempts to perform the operation correctly), but with the later time-sharing facilities these errors can be detected, localised and dealt with by an interruption routine. This fact has given rise to another use of the words program interruption to describe this situation which formerly would have stopped the machine. This procedure may take place through the *scanning* or *break-in* system used to interrupt one series of instructions to deal with another, but it is itself a program interruption in the sense that the course of the program is broken to deal with the event. The term *diagnostic routine* rather than *program interruption routine* would probably be a better one to use for the sake of clarity.

Another confusion could arise when peripheral units in a time-sharing system are sometimes spoken of as having their own control units (i.e. units for sending back the necessary signals to the main control unit). This invites comparison with the multiple control units in certain computers where, in fact, no such comparison is valid. In this paper when describing such features in a time-sharing system the terms *buffer control*, or, where appropriate, *buffer control store*, will be used for the sake of making a distinction.

After the basic techniques for interrupting the program, the next requirement for the time-sharing system is to have some pre-determined set of priorities for these signals received by break-in or by scanning to govern the order in which the Control Unit is switched. This pre-determined set of priorities may be either by hardware (i.e. inherent in the peripheral units) or by program (i.e. priority may be inherent in a master routine or, where there are several programs, each may be accorded a place in a priority list of programs). In the latter case there may be two sets of priorities in effect, for priority is accorded to a program on input according to the use it makes of peripheral units which themselves have an inherent set of priorities.

To return to the actual *break-in* and *scanning* techniques, Table II has endeavoured to make clear that, in the first case, while there are break-in signals which are subject to an overall control and to the chosen system of priorities, there are also others inherent in the hardware for certain types of operations which are outside such a control and which have an overriding priority within their context. This situation seems to have been foreseen and summed up in an earlier paper (*Gill*, 1958): "The master routine might well be a practical solution to handle infrequent interruptions, but would probably be inefficient in the case of frequent interruptions. The correct solution may be a compromise, using built-in circuits to handle frequent interruptions and a master routine for infrequent cases." This appears to be exactly what designers have done, using a master routine for such events as choosing the next program of highest priority (where this situation applies) and built-in circuits for ensuring that block transfers proceed without undue delay once they have been initiated. It should also be

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mentioned that even where interruption features are provided it is possible to disallow these if necessary so that in fact even where these facilities are available, no interruptions take place.

There is another distinction to be made in the use of the scanning technique. Computers can have scanning facilities built in the hardware (i.e. *automatic*), or they can have *programmed* scanning facilities. In the introduction to this paper, and in Tables I–IV, it will be seen that the data processing systems have been classified under two heads: those with automatic time-sharing features (i.e. built into the hardware) and those without such features. It is still, nevertheless, possible for the latter to have programmed time-sharing features, but two machines having programmed scanning systems have been included in the first category because they have other features which can be classed as automatic.

Programmed time-sharing is, of course, by virtue of the reduction in hardware, far cheaper than automatic time-sharing and will reduce the cost of the machines using it. It gives the further advantage that the routine governing the time-sharing which has a pre-determined set of priorities can be fed-out and changed if required.

Advantages and Disadvantages of Time-Sharing versus Multiple-Control Techniques

It is only in a machine with multiple control units that fully parallel programming is achieved. It is pertinent to ask, therefore, whether such fully parallel programming has any advantages over time-sharing.

The first question to be considered is that of pure economics. On the face of it, it would appear to be less costly to divide the use of a control unit between several tasks, to make the maximum use of the already available computer speed, than it would be to duplicate the control apparatus to gain a higher speed. But this argument has not been borne out by the one (French) computer of this type, whose specification is available in the U.K. for study, for this is quoted as having a low basic cost for the potentialities it offers, and the relative cost improves sharply as the amount of equipment is increased.

Again it has been suggested that, while both techniques will produce complications for the programmer, it will be the more difficult to plan for a computer with several control units, for, in this case, it will be important to arrange programs so that the work loads on the various control units are as nearly equal as possible, since having a control unit idle represents a loss of efficiency to the computer as a whole. But there is a difficulty peculiar to the design of a machine with time-sharing facilities and that is that when one program is forced to give way to another some means has to be found to retain the information relating to the state of this program at that time and of restoring it after the interruption. This involves intricacy in design, but does not, of course, affect the programmer once it has been completed.

All in all there does not appear to be any marked superiority of the one technique over the other.

Priority Basis

Where more than one branch of a program, or more than one program, may be run at a time there must be a prearranged priority basis for the control unit to follow, this priority basis not necessarily corresponding to the importance

or urgency of the work. Designers have had different ideas on this subject.

As has already been said, priorities may be inherent in the peripheral units, or else incorporated into a program (i.e. into a master controlling routine if there is one or, where several programs are running together, the programs themselves may each be accorded a certain priority). In cases also where the two types of break-in are used, the one fully automatic and the other within the overall control of a master routine of some kind, there may be two kinds of priority in use at the same time, the one inherent in the hardware and the other established through the master routine, and these two need not be the same. For example, where several programs are in use, priorities for the peripheral units may be established in the hardware, and will be followed during automatic break-ins for block transfers from the store, but the priority accorded to the various programs need not necessarily follow this set of priorities, as the priority of programs is dependent not only on the use they make of peripheral units, but also on their use of the actual processing units.

Where several programs are run at once many different ideas arise as to the best use of the machine. The current conception seems to be in favour of having a *base load*, a continuous program for, say, a production run, which can be interrupted with other programs requiring immediate attention. It should be possible to test out new programs at the same time as doing a production run; it has also been suggested that the *base load* might be a test program for keeping a continual watch on the reliability of the computer. There ought also to be means of getting urgent work through the machine even if this does not correspond with the normal system of priorities.

Advantages and Effects of the Use of Parallel Programming Techniques

The use of these parallel programming techniques enables higher overall speeds of computing to be reached within one system. In particular they minimise the delay due to the varying or slow speeds of peripheral units, since other work can proceed while these are operating, and, in fact, they will encourage the on-line use of a variety of these devices in place of the present practice of having off-line conversion units, because they will not now hold up the work of the computer. In fact all forms of concurrent operation imply that peripheral units of slower speed are acceptable, whereas sequential operation implies the use of units with speeds that are as fast as possible. There is also the advantage that any newly-developed peripheral units can be incorporated into the present system at their own speed without involving changes in its operation.

For the same reason, and since the computer can organise the transfer of information in units of the size it requires, the need for buffer stores, which add to the cost, will diminish. There is also the tendency to rationalise buffer storage by using existing stores or common units for this purpose. The use of fixed blocks in processing will tend to disappear, partly as a consequence of this and partly also of the breaking-up of the fixed word length.

More ready facilities will be available for interrogating large stores for quicker answers to casual enquiries. Real time applications will be encouraged, in particular the use of general-purpose computers for process control, for it need not be a full-time occupation for them: they can do the short-term calculations required to correct conditions in the plant merely by interrupting a longer set of calculations.

Another example of the new ideas which these techniques bring in their train is the suggested change in the recording of file information on a magnetic tape unit. Hitherto this has been done sequentially on successive tape units, the units then being used in sequence by the computer. Indeed, if these tapes had to be printed out off-line this method of recording was the only one possible as a line printer will operate from only one unit at a time. But with parallel programming techniques a more logical way would be to record the items of the file over several tape units and use them in parallel for the computer will run through the file quicker this way; there is no difficulty in printing out as this is done on-line through the computer.

Again, if one thinks in terms of running many programs at a time, other advantageous possibilities appear. Program-testing can take place at the same time as production runs: test programs to check the machine can be run concurrently with normal work; data for processing or requests for information can be dealt with almost as soon as received, provided they come in computer language, as they could, say, through line transmission. The only disadvantage one can think of is the fact that the actual operation of the computer is made so much more complicated; the operator's task becomes more exacting. Indeed, one manufacturer envisages his computer being run by a master operator seated at the control desk directing other operators, much reduced in status, in the comparatively minor work of loading and unloading, etc. A large amount of display is provided on the console for this purpose.

It is possible to speculate indefinitely on the prospect before us. Is it going to be possible to staff these monsters with unlimited appetites for programs? Will the small computer be put out of business? Cannot any work which it does be done more cheaply and with little or no delay by obtaining time (in exceedingly small quantities if necessary) on a large computer with multi-programming facilities? Will the large computer extend its hold over all available processing to such an extent that we shall see the field reduced to a few of these systems, or perhaps, even only one, to which all work would be referred, and that probably through line transmission equipment which will need to be vastly superior to what it is today?

CHANGES IN THE USE OF THE WORD LENGTH

The first computers to be built were designed primarily for scientific computation and their application to business problems did not begin until about 1954. It then became evident that the philosophy behind these early computers was not necessarily valid for business machines, and one of the conceptions which has undergone a gradual evolution has been that of the use of a fixed word length. In the first computers, and persisting right through to some of the latest designs, this fixed length consisted of a set number of bits, used in normal binary code to represent any signed number, a group of alphabetic characters or one or more coded instructions, with perhaps some extra bits for checking. Such an arrangement would certainly seem to be the most suitable for scientific and technical work but it has not, in fact, been confined to scientific machines for even some of the latest designs for commercial data processing have this feature. The number of bits in the word length has increased since the first computers were made, from something like 32 bits which used to be a common length, to over 40 bits.

Machines designed specifically for commercial data processing have also evolved a word length consisting of a set number of characters (or sometimes decimals), each character being coded in a certain number of bits as before, but this group of bits moves in parallel through the machine, although the characters themselves move serially. A natural development of this later form is to make the number of characters in the word length variable.

One consequence of this break-up of the fixed word length, at any rate in computers to which it applies, is the disappearance of the fixed block transfer principle which has dominated later computers of the first generation. The size of the block, usually chosen to accommodate the longest entry, and its speed of transfer greatly affected the overall speed of operation of the computer, in particular the availability of the magnetic tape. The block was an arbitrary unit and higher speeds should result from the use of data in its more natural form. Parallel programming techniques have also tended towards the abandoning of the fixed block transfer principle. Data are still transferred in blocks but the block is now variable.

VARIATIONS IN THE ADDRESS SYSTEM

The number of addresses in a computer is the number of storage locations that can be specified by a single instruction. In a 1-address machine only one storage location is specified in each instruction from which or to which information is to be relayed. In 2-address machines instructions specify two storage locations whose contents are to be added, multiplied, etc., or the contents of one transferred to the other. In a 3-address system these same operations can be performed involving three storage locations (e.g. add the contents of two of them and transfer to the third).

There are, however, variations on this theme. Where instructions are not carried out serially under the operation of the control unit, but each instruction specifies the address of the next, this is described here as the $1 + 1$ address, or $2 + 1$ address system (i.e. these are 1-address and 2-address machines with the extra facility of specifying the next instruction in each order). This has led to the so-called "optimum programming" or "minimum-access programming," where the next instruction is chosen to minimise the amount of time wasted between one instruction being obeyed and the next one being read.

Another variation in the address system in computer design is shown where, in some single-address machines, an order may refer, not only to one storage location according to the definition above, but also to an accumulator, thus turning a single-address machine into a quasi-2-address type.

There is still a considerable variety among computers as regards the address system. Multiple-address systems are, in general, faster but more difficult to handle than single-address codes and optimum programming taxes the programmer's skill. But in making these statements no account is being taken of the provision of automatic programming techniques which could change one's attitude towards the problems of programming any particular machine. Again, to say that a machine has a multiple-address system is not necessarily to say that it will be faster than one with a single-address; its overall speed of operation will depend on its other features such as its mode of operation (parallel or serial), its pulse frequency and the speed of access to its high speed stores. Nevertheless, the address system of a computer is one of the chief factors influencing its design and it is interesting to note that, as reference to Table IV will show, there is remarkable diversity of ideas over the address system.

OTHER DISTINGUISHING FEATURES OF INDIVIDUAL COMPUTERS OF THE SECOND DECADE

In addition to those features of the new computers which have been described, concurrent operating facilities, variations in the word length and in the address system, there are others which are particular to individual designs. Some machines use a fixed store as well as a free store, in which machines useful subroutines are wired up once and for all, these being called up by a single instruction in the instruction code. The idea of such fixed routines is not new at all; indeed they are the basis of special purpose computers whose whole concept is that of a fixed program built-in to perform specified pre-determined operations. Other computers have had a few words of fixed orders but this has developed into the design of computers with both fixed and free stores because of the advantages of greater economy and of easier programming which this provides. A far wider range of instructions is available by this method than would otherwise be possible without complicating (and hence slowing down) the arithmetic unit.

For one machine a new type of fixed store has been evolved which consists of a sheet of woven copper mesh in whose spaces can be fitted tiny rods or slugs of magnetic material which raise the mutual inductances between the wires, the pattern of rods corresponding to the pattern of bits of the information stored: where there is no slug inserted there is no connection. All these stores can be wired up as desired: indeed, they can be changed from one day to the next, but this change can be effected more readily because of this new technique employed. The ideal of designers has now enlarged to extend this capability even further and to provide a "changeable fixed store," one in which the changes can be effected in very short spaces of time, say one or two minutes.

Other computers without fixed stores use the macro-instruction technique where one instruction written in the program generates a number of machine instructions. While both techniques involve the calling up of subroutines through an order in the program, fixed store subroutines are closed subroutines inserted into the hardware whereas the others are open subroutines fed in with the program and eventually linked into it.

The most novel feature of another machine is the use of *nesting stores* which, it is claimed, results in extreme simplicity of programming, as well as effecting striking reductions in the size and running time of programs. Briefly, in a 16-word nesting type store, any word transferred to the store occupies the first location and all information in the rest of the store is automatically and simultaneously moved one place along the store. The arithmetic unit operates on the first few locations. For example, the instruction "Radix Convert" takes eight 6-bit characters in the first location, in conjunction with eight corresponding radices in the second location and produces the required binary equivalent in the first location. Simultaneously the contents of the third to sixteenth locations are moved to occupy the second to fifteenth respectively.

Provision for double-length working has long been a feature of computers. This can always be arranged by programming but the more recent machines have been equipped with special double-length accumulators or registers to facilitate it.

Another design technique was formerly known as micro-

programming and renders the design of the machine virtually independent of the order code finally used. The principle is that every instruction requires a sequence of elementary operations (microprograms or micro-orders) to carry it out. But these operations may be common to many instructions and can therefore be built into the computer as separate entities and combined in different ways to provide the instructions required. This is arranged by designing the control unit as a matrix of ferrite cores. For every action available to the programmer there is a matrix core plane to correspond. Thus the addition of a new instruction to the instruction code simply implies another recombination of operations already provided and if there are a large number of these it is possible to provide without much trouble any special facilities required by users.

This technique is distinct from that known as micro-operations. In the former the combination of microprograms is solely the concern of the designer but in the latter it is the programmer who, by selecting the micro-operations, builds up the instruction. The operation part of the instruction is not decoded as in microprogramming but each bit has a separate action within the computer and this action is the performance of a basic logical operation. By using these micro-operations in combination a very powerful single instruction can be built up, each part of which operates at exactly the same time as the others. A very large number of different instructions of this complex kind can be formed. This type of instruction can be repeated a number of times very readily although extracted only once from the store. Each order in this design also contains up to two addresses so that the computer is equipped with a most flexible type of programming which can be at the same time the simplest and the most challenging to a programmer.

In the latter part of the first decade computers were provided with special registers known as B-lines or B-registers (or sometimes *Index Registers* or *Modifier Registers*), which facilitate repeated operation on the numbers contained in a series of addresses (i.e. built-in registers for changing the addresses in a program). *Every* instruction specifies one B-register and the effect is to add the contents of this register to the address part of the instruction *before* it is obeyed. Where it is *not* desired to modify an instruction the programmer can arrange to select a B-register whose content is zero. Instructions can be modified in the course of the programme without the use of B-lines, but their effect is to increase considerably the speed of the process.

In the newer computers this facility has been extended and has undergone changes as far as actual logical design is concerned. Earlier machines had a few, usually seven or eight special registers to fulfil the function of B-lines, but now a much greater number is provided in some way or other. Some of the computers under discussion here have a large number of such registers (the term B-line is not used so much now, being replaced by the terms index registers, etc.). In others the logic is such that, by programming skill, existing registers in the store may be employed as index registers.

The provision of a larger number of such registers and associated sets of instructions implies a greater flexibility and generality of machine functions; it implies also reduction in the overall operating speeds of programs. It can be demonstrated, for example, that in some machines successive developments in the use of B-registers have reduced the program steps required to perform various operations from five or six to one, with a corresponding reduction in execution time.

Another development of a feature found in the earliest computers is that of floating point operations. Where this was once an exceptional built-in facility it is now usual and in some of the latest designs floating point operations are faster than fixed point.

Also noteworthy is the development of a type of working which has been called *pseudo off-line*, where operations take place within the computer but outside the control of the control unit. The same units are used for either *on-line* or *pseudo off-line* working; genuine off-line working involves different units. A greater facility for simultaneous operation is evidently provided by such a facility as well as perhaps greater working speed and economy of units.

The more advanced data-processing systems are notable for the large number of magnetic tape units used to provide the backing store. These are usually linked to the computer by the addition of tape controllers or switching units, each of which governs a module of tape units, and all of which may usually transfer data from one unit simultaneously.

CHECKING FEATURES IN THESE NEW COMPUTERS

There are two forms of check that can be applied to computer operation:

(*a*) built-in error-detecting devices including error-detecting codes, and

(*b*) checks included by the programmer when designing his program.

There has been controversy over the value of the former although it is conceded that they are useful to the maintenance engineer. It is questionable whether the increase in the cost and bulk of the machine, and the decrease in its overall reliability owing to the possible introduction of errors in the checking circuits themselves, are worth the checks afforded to the program, particularly as these do not absolve the programmer from applying his own.

These built-in checks include devices for checking the reading of information into the computer from punched tape or cards, or from the magnetic tape stores, and similarly for checking the output. Devices are also incorporated in auxiliary units for automatically checking the conversion or printing out of data. The actual computing operations can be checked by duplicating the units concerned or by circuits which in effect carry out inverse processes. Numbers or instructions are sometimes checked before they are used to ensure that they have not altered while waiting in the store. This may be done by a parity digit (*see next paragraph*) or by a check sum of all the information in the store. Very necessary also is a device for sensing when a number exceeds the capacity of the store. Probably these devices are of most value where vast quantities of information are involved, large commercial data processing machines usually incorporating a greater number of these automatic checking facilities.

On the other hand the use of special codes in coding the input information to give protection against occasional (but not usually against compensating) errors is widely accepted. These codes will apply throughout the computer processing and are of the same type as those used in data transmission. They include:

(*a*) self-checking codes;

(*b*) parity checking in which one extra bit is added to each character so that the sum of the bits is always either even or odd (a later refinement of this is double parity

checking which consists of adding two extra bits, one to each group of bits within the character);

(*c*) check sums for each word, for each group of characters or for each block of information.

These forms of check persist into computers of the second decade with further types added. More emphasis is now laid on built-in checks since in a complex computer probably running more than one program at a time it is essential to have quick diagnosis of error with the minimum amount of damage, localised as much as possible. Under these conditions it is not so satisfactory to place the onus of checking on the programmer. Machines that do not have so much in the way of the safeguards or checks against eventualities arising in their parallel programming facilities may nevertheless have a vast number of these more usual types of internal checking features.

Full error-correcting codes have not yet been used in computers except that single error-correcting codes have been used on magnetic tape recording. Other methods of checking the recording on magnetic tape are used, some machines in which all data are recorded twice in the twelve or sixteen channels across the width of the tape (i.e. without increasing either the length of the tape used or the processing time). The equivalent pulses are then checked against each other in some way.

Parallel programming techniques have themselves been used to provide new methods of monitoring machines during calculation. It has been shown that with these techniques the main principle is that an error should not stop the machine, as in earlier computers (with many programs running simultaneously this would be fatal), but that the unit involved should interrupt the running of the computer to branch into some diagnostic routine, other programs being unaffected by this procedure. It is also possible for a programmer to debug his program by this means while other programs are running. There is also the novel idea of using a test-program for maintenance as a base load in such a situation.

One could conclude by saying that, in second generation computers, so much is involved in the design that reliability in working is a major consideration, far more important than fancy facilities or even very high speeds, and that consequently all provision for producing and maintaining this reliability is of the utmost importance.

NEW TRENDS IN THE USE OF PERIPHERAL UNITS

Formerly the problem in the use of peripheral units lay in the discrepancy between the electronic speed of the computer and the electro-mechanical speeds of the peripheral devices. A partial solution to this problem lay in the provision of buffer stores between the computer and its peripheral units but it was mainly mitigated by the "off-line" use of such units (i.e. they worked unattached to the computer in their own time and did not impede its speed of operation). Magnetic tape input was used, the tape being produced "off-line" by conversion from the slower input media, punched paper tape and cards.

Apart from progress in the development of the peripheral units themselves and the increase, sometimes great increase, in their speeds (witness a card-reader at up to 2,000 cards/min. and a paper tape-reader at 1,800 char./sec., and a card punch at 300 cards/min.), other solutions to this problem are now available.

In passing, a new concept should be mentioned, that of replacing "off-line" peripheral equipment, chiefly conversion and editing units, by a smaller computer which performs the same functions but as an ancillary to a larger installation. The magnetic tape systems between the small and large computers may be made completely compatible and the ancillary computer can do all the conversion required to feed magnetic tape input to the large installation. Apart from the obvious advantages of this more flexible system, for the ancillary can still be used as a computer in its own right, it is reckoned actually to be appreciably less expensive to instal an ancillary computer in place of conversion units, while, at the same time, increasing the amount of processing that can be done; more work for less money, in fact.

But the greatest change in outlook in the use of peripheral units appears to be coming from the development of the parallel programming techniques themselves. Time-sharing will enable a much larger variety of peripheral units to be attached to the computer and will tend to do away with conversion devices (*Gill*, 1958). In a system where peripheral units operate simultaneously with themselves and with the computing unit and where data can be called for from a unit only as required, with no waste of computer time, there is less and less need for off-line working or for buffer storage. In such a system, almost any type or any speed of input device could be incorporated, even those which are as yet undeveloped. There need no longer be any choice between these different types of media. Communication with the computer for remote locations through data transmission systems presents no problem: neither does the use of the computer in feedback process control.

It has already been observed that the input/output media used for computers have been those already well established in this and other fields. Two new techniques, character-reading and xerography, are on the horizon to change this situation but it is still possible that some development may arise which will cut right across this established state of affairs and revolutionise altogether this aspect of computers: input from the spoken word; the development of other recording media such as digitape or the magnacard (a magnetic card combining many of the virtues of magnetic tape and punched cards), both for input/output and storage; devices such as FOSDIC, developed for use in the U.S. Census, which searches on microfilm and records the results of its search on magnetic tape and devices for the opposite procedure of recording on microfilm either from the computer or again from magnetic tape; any one of these or another development may still establish itself in preference to existing forms of input/output or storage media.

A great feature has been made in recent years of the necessity for random access storage units. As has been said magnetic tape has become the almost universal medium for a file or backing store but access to magnetic tape is not random, this method of storage suffering from the disadvantage that, since its information is stored sequentially, it is necessary to search through unwanted items in order to identify the one required. Even if the particular reel involved is known, the "access time" to an item may still be as much as the time taken to select the reel manually, set it up on the tape-transporting mechanism and run it through (the worst case being where the required item is the last on the reel).

Efforts have been made to get over this difficulty by providing tape buffer store controls for searching the magnetic tape simultaneously with computer operation (this has already been referred to in a previous section) where information from the tape is required during the course of a pro-

gram. Separate interrogation units apart from computer operation have been provided for the magnetic tape file store in some machines. No really satisfactory answer to this problem has yet been found but some equipment has been developed of a random or quasi-random access type which goes some way towards solving this. Of course, magnetic core storage is the ideal random access store, and in fact is used as such for working storage in nearly all computers nowadays, but it is expensive for use on a large-scale, as a backing or file store.

Foremost among these random access units has been the use of multiple magnetic disc stores. These have been attached to computers as random access storage units and they have also been made the basis for a random access computer in which magnetic discs with independent access arms are the only type of storage supplied. Every track in this unit may be referred to at random and up-dated individually, the filed data thus always reflecting the present position.

Another attempt to solve the problem was through the use of large, slow-speed, magnetic drums. The access time here is limited to within one revolution of the drum, a much shorter time than running through a reel of magnetic tape. Yet other solutions have been tried using mutiple short magnetic tape lengths. Lastly there is a newly evolved magnetic file medium for random access which has the advantage that the magazines of information inserted in the units can be changed as can a reel of magnetic tape.

Table III shows which of the second generation computers employs this type of unit. It is legitimate to wonder about their future. In an era of vastly increased computer speeds, time-sharing and multiple control units are they essential: do they even still serve any useful purpose? Cannot any program be so arranged that the access time to even a serial file store is reduced to a minimum anyway? Parallel programming techniques themselves provide a convenient method for searching such a store without unduly delaying the operation of the computer and casual enquiries can be answered in this way without slowing down to any extent the main calculations. Nevertheless the designers of one new British machine have contemplated the use of such a unit, and the recent announcement in the U.S.A. of yet another magnetic disc store computer shows that the subject of random access stores is by no means yet exhausted.

FUTURE OUTLOOK IN COMPUTERS

A vast amount of research work is going on in this country and especially in the U.S.A. into new components for computers. The aim is to find new techniques for switching and storage of greater speed and also to find cheaper components to reduce eventually the cost of computers. John Diebold has called present-day computers "the dinosaurs of the whole computer development" (*Office Management*, **13**, 389, *December* 1959) and any survey of this research into new components has as its aim not to list them and their characteristics (for most of them have not yet been actually used in computers, and it is still doubtful whether some can be) but to discover whether the design of computers is likely to undergo such a radical change as to make obsolete within the next few years even the machine techniques discussed in this paper. Computers are likely to become obsolete in terms of degree, that is to say they will become faster and smaller in size and their programming will become more complex, their peripheral units will improve and their flexibility increase, but is there likely to be any great technological breakthrough which will fundamentally alter their design in the next few years?

Much comment has been made lately on the subject of the limits of computer speed. There is an absolute limit to speed imposed by the speed of light which travels about 1 foot in 1 millimicrosecond. High-speed computers are therefore necessarily smaller computers and the limit of speed is then measured by the time that it takes a pulse to travel 1 ft., and this time can never be less than about 1 μs. This probably means that the ultimate arithmetic speed will not exceed 1 μs. for addition which would require a frequency rate of 1,000 Mc/s, but components are not yet available small enough to give such a frequency.

Will the distinction between scientific and business computers disappear? It does not seem so yet. Many machines have been built which have features making them suitable for either market but, in general, most can still be described as more suitable for one type of work than for another.

As indicative of the uncertain state of the game it could be mentioned that there is still one computer manufacturer that believes in visible records as opposed to keeping information in computer language (either unreadable or not very easily readable) and has backed this belief to the tune of £5 million of research leading to the production of what is now termed a Visible Record Computer. For certain types of commercial work, banking, stores control, etc., they may very well have taken the right line. In this VRC computer records may be read by the human eye in legible written characters throughout all stages of the processing, input, storage, results. And who can say whether this may yet be considered the right approach in the commercial field?

A whole range of studies has been initiated now by the British Standards Institution with the aim of arriving at some standards as a basis for developments in this field. These studies cover computer components and ancillary equipment, methods of coding and nomenclature. Their importance is obvious; they facilitate interchange between one installation and another, and consequently between one firm and another, one industry and another and even it is hoped between one country and another.

The B.S.I. are forming a Data Processing Industries Standards Committee in parallel with the present Mechanical Engineering Industry Standards Committee, to which most of its present data processing committees and panels finally report. When this takes place all the existing committees dealing with data processing topics will be responsible to this new Standards Committee. This alteration in the structure of the B.S.I. Committee work marks the recognition by that body of the emergence of an important new British industry. Steps have also been taken through the International Organisation for Standardization (ISO) to arrive at some international, or at any rate European, standards in this work.

As far as input codes are concerned, a common hope has been expressed within the B.S.I. committees that the codes used for both paper and magnetic tape should be the same, and indeed that all coding on paper tape, magnetic tape and punched cards should be compatible, this to be agreed as soon as possible as a basis for future development. In fact, a single coding system for all media for international usage is the final objective.

Above all the future of computers is governed by this pernicious question of the cost. All through this paper it has been a recurring theme: it has governed the development of storage facilities in computers, it is one part of the drive

behind the search for newer (and cheaper) components, it is indissolubly tied up with the question of reliability; it will govern the choice between using a small computer or obtaining time on a larger machine; it is the operative factor in assessing the value of using automatic programming methods; it is the basis of the philosophy that the machine, in particular a very fast machine, should never be idle and consequently the foundation of the new parallel programming techniques.

This might very well be a suitable place to add a note on the absolute necessity of bringing these new computers into use. Only by using them can their differing designs be fully tested out. As it is designers are racing ahead and producing new ideas which are not yet fully tested in the field. It could safely be said that at the present time study of the applications of computers is more necessary than the development of new equipment. Only by using them can their full potentialities and perhaps their optimum design be revealed, and the industry is at present suffering from the reluctance of users to pioneer in this field.

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Note to the Tables (on following pages):

While every care has been taken in compiling the following tables (and wherever possible the data has been checked by the relative manufacturer) neither The British Computer Society nor The British Transport Commission accept any responsibility for the facts stated.

The Society wishes to express its thanks to the British Transport Commission and to the author, Miss D. E. Kilner, for permission to reproduce them.

Table I

CONCURRENT OPERATING FACILITIES

Name	*Number of Control Units*	*Number of Programs that can be run together*	*Parallel Programming Features* / *Simultaneous Operation of Peripheral Units*	*Buffer Stores to Peripheral Units*	*Off-Line Facilities*	*Remarks*
High-Speed Scientific Computers and Data Processing Systems						
FERRANTI ATLAS	1	Several, up to a maximum of 8.	A system based on each peripheral unit calling up its own associated subroutine from the Fixed Store under the overall control of a Fixed Program called the Supervisor and using a Floating Block Address System.	Virtually none.	None normally necessary.	The Magnetic Drums are treated as peripheral units in the Time-Sharing System, but are used in such a way that they and the magnetic cores constitute a single-level store to the programmer.
IBM 7030 (STRETCH type Computer)	1	Up to 34.	Up to 32 peripheral units operate simultaneously—one on each channel. Execution of programs associated with each interleaved under combined program and hardware control. Additionally simultaneous transfer from disc storage.	Exchange system provides complete buffering.	None normally necessary. An IBM 1401 computer may be used if desired.	Up to 8 magnetic tape units can be associated with a channel. All transfers of information between core storage and peripheral equipment is via Exchange; this does not tie up the Central Processing Unit in any way. Facilities for real time and remote operation.
High-Speed Scientific Computers						
IBM 7090	1	Up to 9 in theory, but only about 3 in practice.	8 data channels (each one with up to 10 tape units plus card reader, card punch and printer) operate completely independently with their data transmission activities time-shared by the Multiplexor (Exchange) unit through an electronic scanning system with Automatic Priority Processing.	Exchange system provides complete buffering.	An IBM 1401 computer will normally provide all off-line facilities.	This computer also has facilities for real-time working.
ELLIOTT 502	1	Up to 10; theoretically based on number of priorities available.	Controlling Program allocates operating time to programs on basis of time dependence in response to break-in signals generated internally or by peripheral devices. Data transfers initiated by program operate simultaneously and independently of program on up to 8 channels on hardware priority.	Minimised buffer control stores of normally one word only. Transfers direct to program-defined store areas.	Dependent on real-time application. Normally unnecessary.	This computer is designed specifically for real-time working. Peripheral equipment will normally be special to applications as well as conventional input, output and file equipment.
ELLIOTT 503	1	2, normally in the form of a *base-load* program and a *priority* program.	There is priority processing under the control of an organising routine, but limited to two programs, one a *base-load* and the other a *priority program.*	None.	None.	
ENGLISH ELECTRIC KDF9	1	Up to 4 independent programs.	A supervisory routine allocates storage space and peripheral devices to a program on input and handles the program breaks. Priorities are allocated to the programs by the operator.	Virtually none.	Transcribing and converting operations, (e.g. printing from magnetic tape or writing magnetic tape from cards) may be performed either on-line or off-line on separate equipment.	Most peripheral units are reserved at any given moment to a particular program, but there is a monitor printer and input keyboard accessible to all programs and to the supervisory routine.

Data Processing Systems with One Control Unit

(i) *with automatic time-sharing features*

AEI 1010	2 the long and the short control units.	In principle unlimited, the actual number being subject to the availability of storage and peripheral units.	A system based on scanning of the peripheral units as well as some break-in facilities under the overall control of a Housekeeping Routine called the Pro-program Switch.	Each of 32 peripheral units has its own buffer store control.	Off-line conversion and interpretation units provided.	This computer was also planned to have separate on-line interrogation to a Random-Access File Drum, but this latter has now been shelved in favour of magnetic core units for random access purposes, if required.
FERRANTI ORION	1	In principle unlimited, but in practice up to about 3 or 4.	A system in which each program is given a place in a Program Priority List which is scanned by an overall Time-Sharer Routine after break-in signals have been received from the peripheral units. A Reservation principle and Lock-Out system ensure that there is no possibility of one program impinging on another.	A buffer control store of 2 words to each peripheral unit including the drums.	None normally necessary.	Design of this time-sharing system has been the result of simulation studies on PEGASUS and SIRIUS. All peripheral units are connected directly to the magnetic core store in a uniform manner for all types of equipment and direct transfers take place simultaneously with computation, under the time-sharing system. This applies to input, output, tape and drum units. A maximum of 125 devices (other than drums) may be connected.
LEO III	1	Several, usually in the form of one main program with subsidiary compatible programs.	Overall control is in the hands of a Master Routine (not fixed) in which priorities are established for dealing with break-in signals sent back from peripheral units, but access to the core store is governed by a Store Access Control Unit, each peripheral unit being connected to this through an Assembler Unit, transfers to and from these Assembler Units being automatically time-shared after initiation.	One or two words for transfer from each peripheral unit. The core store itself is used as a buffer store when required.	Operations usually expected to be on-line, but off-line units can be provided by connecting up the two required units with their respective Assemblers. The Assemblers have been engineered especially to provide this.	
IBM 7070	1	Theoretically about 8, but in practice up to 3.	Transfers between the peripheral units and the working store (including interrogation of the RAMAC units) along the 4 transfer channels are time-shared by an electronic scanning system, the priority basis for switching being ultimately under the direct control of the programmer.	The 4 input/output transfer channels are fully buffered, as are the punched card and on-line printer channels.	An IBM 1401 computer will normally provide all off-line facilities.	There are also separate interrogation facilities to the random access stores.
IBM 7080	1	Theoretically several, but only up to 3 in practice.	Ditto for the 5 transfer channels.	The 5 input/output transfer channels are fully buffered and controlled by the exchange unit.	An IBM 1401 computer will normally provide all off-line facilities.	RAMAC units are not a standard feature of this system.

Table I—CONCURRENT OPERATING FACILITIES—*continued*

Name	Number of Control Units	Number of Programs that can be run together	Parallel Programming Features	Simultaneous Operation of Peripheral Units	Buffer Stores to Peripheral Units	Off-Line Facilities	Remarks
Data Processing Systems with One Control Unit (contd.)							
(i) *with automatic time-sharing features* (contd.)							
EMIDEC 2400	1	No specific limitation.	Completion of each peripheral unit transfer gives a "program inter-rupt," causing the computer to enter a supervisory routine, which controls time-sharing between unrelated programs.	The computing unit has 4 input-output channels, to which peripheral units are connected by the switching unit, by program or manual control. These channels are scanned automatically and transfers between main store and peripheral units proceed autonomously. Input, output and computing operations can therefore proceed simultaneously	The four computer input/output channels are each equipped with a 2-word buffer store.	Off-line units are available for Card and Paper Tape input, Card and Printer output, and Magnetic Tape File Searching.	
NCR 315	1	1	A system in which automatic break-in occurs from peripheral units provided the programmer permits them.	All buffered units will work simultaneously with the actual processing.*	Output units, the magnetic ink sorter/reader, and enquiry stations have buffer stores.	—	* Computing may take place also in parallel with random access store selection.
ENGLISH ELECTRIC KDP 10	1	1	There is an automatic break-in facility by which any input or output operation can proceed simultaneously with computing or an input and an output operation can proceed together.		All input/output units are buffered.	Comprehensive range of ancillary equipment for on- and off-line operation. Conversion between cards and magnetic tape off-line; printing on-line or off-line from magnetic tape.	Simultaneous performance of operations with dual instructions in virtually single instruction time.
ICT 1301	1	1	Transfers between input/output units and the working store are time-shared through programmed scanning, but there is an automatic break-in technique for transfers between the magnetic tape units and the working store.	Computations proceed simultaneously with transfers between the working store and peripheral units, *but* magnetic drum operations cannot be carried out at the same time as input/output transfers.	None: the working store is used instead with special transfer facilities (cols. 4, 5).	None.	

Data Processing Systems with One Control Unit (contd.)							
(ii) *without automatic time-sharing features*							
EMIDEC 1100	1	1	-	Up to 16 peripheral units may be connected on-line. These units operate simultaneously with central computer working.	Each peripheral unit is equipped with an independent magnetic core buffer store and control.	Line printers, card readers and magnetic tape units may be connected on-line or off-line.	
STANTEC COMPUTING SYSTEM	1	1	—	There is simultaneous operation of the computer and magnetic tape input/output.	Buffer storage provided in blocks (ferrite) of 32 words and up to 8 such blocks may be linked to the system.	Some provided notably off-line printing, but on-line operations mainly.	Some of the input/output units write or read direct on to magnetic tape directly under computer control.
IBM 1401	1	1	—	There can be simultaneous operation of the computer and input/output units.	In general, none, but there is a print buffer.	None.*	* This computer is itself used to provide off-line facilities to larger IBM systems.
Data Processing System with more than one Control Unit							
BULL GAMMA 60	Each functional unit has its own control unit for autonomous operation.	Virtually unlimited number of unrelated program simultaneously.	A system based upon the allocation of instructions and data by the Main Control Unit, called the Dispatcher, according to requests received from the individual control units.		None.	None.	
Smaller Systems announced from 1959 *onwards*							
(i) *with automatic time-sharing features*							
NATIONAL-ELLIOTT 802/803	1	1	Operations are under the control of a Master Controlling Subroutine (which is *not* fixed) which acts according to signals received from regular scanning of the input devices or from interruption by other parts of the machine.	—	None.	None.	Originally designed for use in Process Control. *Computer Journal*, **2** (4), 185–188, January 1960.

Table II

TECHNIQUES FOR PROVIDING PARALLEL PROGRAMMING FACILITIES

Name	OVERALL CONTROL		SCANNING FEATURES		BREAK-IN FEATURES		SYSTEM OF PRIORITIES		Remarks
	by Program	*by Hardware*	*by Program*	*by Hardware*	*within the Overall Control*	*outside the Overall Control*	*by Program*	*by Hardware*	
High-Speed Scientific Computers and Data Processing Systems									
FERRANTI ATLAS	By a Program in the Fixed Store called the Supervisor.	—	A Time-Scanner checks the engaging or disengaging of new equipment before and after incorporation into the Program Priority List: cycle time is 1 second, including the scanning of the 32 tape units.	—	Each peripheral unit sends back signals to the Supervisor which then scans the Priority List to find the program of highest priority free to proceed.	Signals from the buffer controls cause the Control Unit to *hesitate* while the buffers make prior use of the store, but only in the transfer of one or two words at a time during block transfers from magnetic drums or tape.	A Program Priority List is established in the Store which the Supervisor scans.	—	Each peripheral unit operates independently under the control of its own corresponding subroutine held in the Fixed Store. Priority is allocated to a program on inpu according to information presented with it to the machine, but in the last analysis it can determine its own Program Priority List to enable the most efficient use to be made of the system.
IBM 7030 (STRETCH type computer)	By a monitoring program.	—	Each peripheral unit sends back signals which are scanned by the monitoring program.*	Automatic interrupt system on all sections of system.	—	Transfers between the exchange and the store take place under auxiliary hardware control.	Priority is under the control of the monitoring program.	Priority signals automatically generated.	*Consoles are thought of as input/output devices. Information referring to any specific program can be set up on the console by switches whose settings are then interpreted by the monitoring program.
High-Speed Scientific Computers									
IBM 7090	An Automatic Priority Processing Routine, a fixed program in the Store, but this can be overruled by the programmer.		—	An electronic scanning system covers the 8 data channels (including interrogation to RAMAC).	—	—	Priority initially fixed in the Hardware through the Automatic Priority Processing Routine, but this can be overruled by the programmer or from the operator's console.		—
ELLIOTT 502	A Controlling Program for each real-time application controls time-sharing of the control unit between programs of differing time dependence.	In conjunction with the Controlling Program, restricts break-in to currently permissible programs.	May be used in cases of multiple devices sharing a single priority.	—	Internally or externally generated break-in signals of higher than current program priority cause program interruptions.	Automatic data transfers one word at a time independent of current program on a hardware priority basis.	Determined by time dependence of real-time programs for each application individually.	For data transfers based on transfer rates.	Real-time applications place critical emphasis on time-sharing facilities.
ELLIOTT 503	By an organising program.	—	May be used for concurrent operation of more than two programs.	—	Control reverts to the *base-load* program whenever the *priority program* is held up and reverts back when it can proceed.	Automatic break-in for one word transfers between peripheral units and store.	Inherent in the organising program which takes the *priority* before the *base-load program*.	—	All programs written for 803 will run on the ELLIOTT 503. It is anticipated that the 503 will be used as the centre of a system of 803 computers.

High-Speed Scientific Computers (contd.)

ENGLISH ELECTRIC KDF9	—	By a supervisory routine (a fixed program).	—	—	Break-in signals are sent back from the peripheral units (when a high-priority program is either held up or ready to resume) to the supervisory routine which then selects the next program according to the system of priorities.	Peripheral block transfers are autonomous on break-in basis after they have been initiated.	Priorities are allocated to programs by the operator.		A peripheral block transfer initiated by a single instruction may be of any number of words and may refer to any part of the main store area allocated to the program concerned.

Data Processing Systems wtih One Control Unit

(i) *with automatic time-sharing features*

AEI 1010	By a Housekeeping Routine known as the Program Switch which acts on information received from the buffer control units.	—	—	A Data Scanner in the Control Unit scans 32 peripheral units at regular intervals as well as the main computer and interlaces the transfers from them word by word with the execution of computer instructions.	There are certain break-in and interrogation features, operating by manual input through the Program Switch which can seize or delay the Control Unit after which it returns to its previous operating schedule.	Following a block transfer instruction the succession of single word transfers between the store and the peripheral units is carried out automatically through a break-in technique.	Priority normally inherent in peripheral devices, the fastest units having first priority, but this can be overridden if required by writing an *uninterruptable* program. Urgent work can also be executed by break-in from the Console.		—
FERRANTI ORION	By a Time-Sharer Routine and a supervisory Organisation Program.	Special equipment prevents attempt by any program to interrupt another.	—	—	Signals from the peripheral units are sent back to the Time-Sharer Routine which then finds the first program in the given order of priorities which is free to proceed.	Signals from the buffer controls cause the Control Unit to *hesitate* while the buffers make prior use of the Store in single word peripheral unit transfers during block transfers.	A Program Priority List is established in the Store which the Time-Sharer Routine scans.	—	Priorities are allocated to programs on input to the machine according to external ratings given by the programmers, ratings determined by the use made of the computer and of the peripheral units which themselves are accorded an initial priority in the hardware.
LEO III	By Master Routine which is expected eventually to be a general purpose routine, but may initially be devised for individual programs.	—	—	—	Break-in signals are sent back from the peripheral units (when a high-priority program is either held up or ready to resume) to the Master Routine which then selects the next program according to the system of priorities.	Access to the Core Store is automatically time-shared after transfers have been initiated, the fastest units having an inherent priority.	Priorities inherent in the Master Routine, the fastest units generally being given priority, but higher priority would be given to a program making little use of the arithmetic unit itself.	—	

Table II

TECHNIQUES FOR PROVIDING PARALLEL PROGRAMMING FACILITIES—*continued*

Name	*OVERALL CONTROL*		*SCANNING FEATURES*		*BREAK-IN FEATURES*		*SYSTEM OF PRIORITIES*		*Remarks*
	by Program	*by Hardware*	*by Program*	*by Hardware*	*within the Overall Control*	*outside the Overall Control*	*by Program*	*by Hardware*	
Data Processing Systems with One Control Unit (contd.)									
(i) *with automatic time-sharing features* (contd.)									
IBM 7070	An Automatic Priority Processing Routine, a fixed program in the store, but this can be overruled by the programmer.		—	An electronic scanning system covers the 4 transfer channels (including interrogation to RAMAC).	—	—	Priority initially fixed in the hardware through the Automatic Priority Processing Routine, but this can be overruled by the programmer.		—
IBM 7080	Ditto		—	Ditto (without the RAMAC feature) for 5 transfer channels.	—	—	Ditto		—
EMIDEC 2400	By supervisory routine, entered on receipt of a "program interrupt" from a peripheral unit.	—	—	The buffers of the 4 input/output channels are scanned at regular intervals.	—	A "program interrupt" is given whenever a peripheral unit requires attention.	This is a function of the supervisory routine.	—	After scanning, control may be transferred to a program interruption routine (one is associated with every program run) to deal with the events which have been indicated by control characters on the tape. Connections between peripheral units are made through the Switching Unit either *on-line* through the computer or *off-line* through manual input control.
NCR 315	A system in which automatic break-in occurs from peripheral units provided the programmer permits them.		—	—	Automatic break-in occurs from peripheral units.		Under the control of the programmer.	—	—
ENGLISH ELECTRIC KDP 10	A system in which automatic break-in occurs from peripheral units provided the programmer permits them.		—	—		Automatic break-in facility for peripheral transfers to or from the core store in units of 4 characters.	Under the control of the programmer.	—	There is a range of powerful data handling instructions.
ICT 1301	By PPF Routine (Punching, Printing, Feeding).	—	The PPF Routine scans the input/output units at regular intervals to time-share the transfer of data between them and the working store.	—	—	An automatic break-in technique gives priority over other operations to tape transfers to the working store.	Priorities incorporated into the PPF Routine.	—	In fact there are 15 different versions of the PPF Routine giving 15 different sets of priorities. Reading and writing magnetic tape can be effected concurrently with the operation of input/output units.

Data Processing System with more than one Control Unit									
BULL GAMMA 60	—	By Master Control Unit called the Dispatcher (comprising the Program Distributor and the Data Distributor).		—	Break-in signals are sent back from each autonomous unit requesting further instructions and/or data; these queue up to be dealt with by the MCU according to the system of priorities.	—		A set of priorities for the autonomous units is built into the hardware; no priority is given to the various programs. The slowest units have priority.	Each autonomous unit has its own control unit and all such units can operate simultaneously.
Smaller Systems announced from 1959 onwards									
(i) *with automatic time-sharing features*									
NATIONAL/ ELLIOTT 802/803	By Master Controlling Subroutine which acts according to the digits in the Control Word (see Cols. 4 and 6) which it scans at regular or short intervals.		Input measuring devices are scanned at fixed intervals and signals sent back to form the Control Word (39 digits in length). Scanning is under the control of the MCS and its timing under the control of a digital clock.		Signals also sent back to the Control Word from the Manual Input or as a result of a calculation; the electromechanical input devices (tape, typewriters, etc.) also send back signals to indicate their freedom for use.	—	Inherent in the Master Controlling Subroutine which searches the Control Word for the digits of highest priority.	—	System designed for process control applications in particular. The MCS is fed in initially through the paper tape input units which are then locked to prevent interference.

Table III
FORMS OF STORAGE

Name	Date		Working		Main		File		Fixed		Random Access File Store		Remarks
	An-nounced	Com-pleted	Type	Speed	Type	Speed	Type	Speed	Type	Speed	Type	Speed	
High-Speed Scientific Computers and Data Processing Systems													
FERRANTI ATLAS	June 1959	1961/62 †	Ferrite Cores: 4,096 word units expand-able up to 262,144 words. Also 128 B-registers.	Cycle time 2 µs.* Access time ½ µs. Access time 0·3 µs.	Up to 16 Mag-netic Drums of 24,000 words each. (Up to 40 drums may eventually be attached.)	5,000 r.p.m.	Up to 32 Magnetic Tape units (Ampex FR-300) with 8 tape control units.	Up to 90,000 char./sec.	Ferrite Slugs of minimum capacity 4,096 words.	Speed of access is 0·3 µs.	Large random access stores may be attached.	—	†Pilot model working 1960. *Simultaneous access to different sections of store gives a 1 µs. effective cycle time.
IBM 7030 (STRETCH type computer)	1960		Ferrite Cores: up to 262,144 words (each of 64 bits plus 8 check bits).	Readout cycle varies upwards from 0·4 µs. Overlapped storage output.	—	—	Up to 32 channels may be used for all types of peri-pheral units (apart from disc) with up to 8 Magnetic Tape units per channel.	5,864 words/ sec.	—	—	Disc storage units (up to 4 mill-ion words per unit) may also be attach-ed with a transfer rate of 125,000 words/ sec.	—	—
High-Speed Scientific Computers													
IBM 7090	January 1959		Magnetic Cores: 32,768 words.	Machine cycle time is 2·18 µs.	—	—	Up to 80 units of Mag-netic Tape.	2,500 or 10,000 words/ sec. per unit at choice.	—	—	RAMAC units if required (Magnetic Discs).	—	—
ELLIOTT 502	August 1960	End of 1961	Magnetic Cores: 1,024 words of 20 bits each.	Core cycle time is 1 µs.	Magnetic Cores: by units of 8,192 words to virtually unlimited amount (20-bit words).	Core cycle time is 5 µs.	(i) Magnetic Tape. (ii) Magnetic Film.	Up to 90,000 char./sec. Up to 6,000 char./sec.	—	—	—	—	All Main store locations individually addressable. Buffer control stores normally reduced to a minimum of 1 word only by use of high-speed automatic data transfers from Working or Main Stores.
ELLIOTT 503	1960–1962		Magnetic Cores: (i) 4,096 words, or (ii) 8,192 words.	Core cycle time 5 µs.	—	—	Magnetic Tape (Potter 1″ Magnetic Tape Units).	270,000 bits/sec.	—	—	Virtually infinite Ferrite Core storage for data can be added.		—
ENGLISH ELECTRIC KDF 9	August 1960	1961	2 sets of nesting stores and 15 multi-purpose registers.	Access Time ½ µs.	Magnetic Cores: 4,096 words by blocks of 4,096 words to 32,768 words.	Core cycle time is 6 µs.	Magnetic Tape Units (unlimited number) of various types.	Up to 90,000 char./sec.	—	—	As dictated by individual require-ments.		The input/output chan-nels are capable of handling data from any available peripheral device (subject to maximum total trans-fer rate of 1·33 million cha./sec.)

Data Processing Systems with One Control Unit

(i) with automatic time-sharing features

AEI 1010	—	1960	Magnetic Cores in units of 2,048 or 4,096 words.*	Core cycle time is $8\frac{1}{2}$ μs.	Up to 4 Magnetic Drum units usually of 8,192 words each, although 25 is the actual maximum number.	3,000 r.p.m.	Up to 16 Magnetic Tape units (Ampex FR-300 or Decca).	Up to 90,000 char./sec.	—	—	Project for a low-speed Magnetic Drum shelved in favour of extra magnetic core store units.	300 r.p.m.	*Extra units of Magnetic Core storage may be connected through any of the 32 peripheral equipment channels.
FERRANTI ORION	Nov. 1959	1961	Magnetic Cores: from 4,096 to 32,768 words by steps of 4,096 words.	Core cycle time is 12 μs.	Magnetic Drums normally provided in units of a pair, with each drum holding 16,384 words, but single drum units can be provided.	2,500 r.p.m.	Up to 16 Magnetic Tape units (Ampex FR-300).	Up to 90,000 char./sec. per control unit.	—	—	—	—	All storage locations are directly addressable. A virtually unlimited number of drums may be attached. Tape units and other peripheral devices interchangeable between ORION and ATLAS.
LEO III	1959	1962	Magnetic Cores: 4 × 4,096 words (a second unit of the same size may be added if required).	Core cycle time is 16 μs.	—	—	Up to 64 Magnetic Tape units (of ½" reels) in two groups of 4 Assemblers with 8 units to each Assembler.	45,000 char./sec. (1" units giving up to 90,000 char./sec. may also be attached).	—	—	—	—	—
IBM 7070	September	1958	Magnetic Cores of 50,000 or 100,000 digits.	Machine cycle time is 6 μs.	—	—	Up to 40 Magnetic Tape units.	Either 42,000 or 62,500 char./sec.	—	—	Up to 4 units each of 12,000,000 digits of RAMAC (Magnetic Disc) storage.	—	—
IBM 7080		1960	Magnetic Cores of 160,000 char. including the exchange storage.	Machine cycle time is 2·18 μs.	Up to 30 Magnetic Drums, each with a capacity of 60,000 characters.	8 μs. average access time.	Up to 50 Magnetic Tape units.	Either 42,000 or 62,500 char./sec.	—	—	—	—	The exchange storage is used for transfers between tape units and the main store, and also between areas of core store.
EMIDEC 2400	1955	1960	Diode-Capacitor elements, 64 words.	Cycle time 4 μs. giving access time of 1·5 μs.	Magnetic Cores (Random Access) 4,096 words to 16,000 words eventually.	Core cycle time 15 μs.	Up to 30 units of 1" Magnetic Tape: each reel stores over 5 million characters.	20,000 char./sec.	—	—	—	—	Designed to be particularly suitable for updating a large file of information. The 1" magnetic tape is used for interconnecting and routing data throughout the system. Each of the peripheral units works from or prepares a similar magnetic tape. There is no random access file store, but there is a file search unit for the 1" tape store which can be used on- or pseudo off-line.

Table III—FORMS OF STORAGE—*continued*

Name	Date		Working		Main		File		Fixed		Random Access File Store		Remarks
	An-nounced	Com-pleted	Type	Speed	Type	Speed	Type	Speed	Type	Speed	Type	Speed	
Data Processing Systems with One Control Unit (contd).													
(i) *with automatic time-sharing features* (contd.)													
NCR 315	1960	—	Magnetic core store of 2,000, 5,000, 10,000, 20,000 or 40,000 words	Core cycle time is 6 μs.	—	—	Up to 8 Magnetic Tape units available.*	40,000 or 60,000 char./sec.	—	—	Over 5 million characters	Variable access time. Random selection off-line. Transfer rate 100,000 char./sec.	*Up to 16 magnetic file units altogether of which not more than 8 may be magnetic tape. Tape optionally compatible with IBM machines.
ENGLISH ELECTRIC KDP 10	1959	1961	Magnetic Cores: up to 16 units, each of 16,384 characters to a total of 262,144 char.	Core cycle time is 15 μs.	—	—	Up to 62 Magnetic Tape units.	33,000 or 66,667 char./sec.	—	—	—	—	Completely flexible data layout gives economy in store and magnetic tape usage and increased speed of operation.
ICT 1301	May 1960	1960	Magnetic Cores: from 400 to 2,000 words (in steps of 400).	Core cycle time is 12 μs.	Magnetic Drums: up to 8 units of 12,000 words each.	5,240 r.p.m.	Magnetic Tape: (*a*) *Standard:* Up to 8 units of about 12,500,000 digits each. (*b*) *High Performance:* Up to 8 units of 25,000,000 digits each.	22,500 digits/sec. 90,000 digits/sec.	—	—	—	—	There are two types of transfer from the magnetic drum to the Magnetic Core store: by decade (10 words) with average access time of 5·8 ms. and channel transfer of immediate access time, comprising 20 decades (200 words).
(ii) *without automatic time-sharing features*													
EMIDEC 1100	1957	1959	1,024 words on Magnetic Cores, but may be expandable up to 4,096 words.	Core cycle time is 15 μs.	Up to 4 Magnetic Drums of 16,384 words each.	2,650 r.p.m.	A number* of Magnetic Tape units of 900,000 words per reel.	20,000 char./sec.	—	—	—	—	*Up to 16 peripheral units of all types may be attached. A buffer store of 396 chars. is provided for each tape unit, and 198 chars. for other units.
STANTEC Computing System	1960	—	Ferrite Cores in blocks of 512 words.	—	Magnetic drum of 8,192 words.	6,000 r.p.m.	Up to 32 Magnetic Tape units of 2 types may be attached.	(i) 120,000 char./sec. (ii) 15,000 char./sec.	—	—	—	—	—
IBM 1401	October 1959		Magnetic Cores: 1,400 to 16,000 alphameric chars.	Machine cycle time is 11·5 μs.	—	—	Up to 6 Magnetic Tape units of either IBM 729, Model II or IV.	From 15,000 to 62,500 char./sec.	—	—	—	—	—

Data Processing System with more than one Control Unit													
BULL GAMMA 60	Early 1958	1960	Magnetic Cores: 1 to 8 units each of 4,096 catenae.	Core cycle time is 10 μs.	Magnetic Drum: 25,600 words.	3,000 r.p.m.	Unlimited number of Magnetic Tape Units.	15,000– to 22,500 char./sec.	—	—	—	—	—
Smaller Systems Announced from 1959 onwards													
(i) *with automatic time-sharing features*													
NATIONAL-ELLIOTT 802/803	1958	1959	Magnetic Cores: either (i) 1,024 or (ii) 4,096 words.	—	—	—	Magnetic Film units can be fitted.	1,800 char./sec.	4 of the words in the Magnetic Core store have fixed orders.	—	—	—	—
(ii) *without automatic time-sharing features*													
BULL 300 DP Series	June 1960		—	—	Magnetic Drum of 200,000 dec. digits, with 4 associated QAS stores.	2,750 r.p.m.	Up to 8 Magnetic Tape units under the control of a Multi-selector unit which itself has 3 blocks of ferrite core storage of 192 dec. digits each.	22,500 char./sec.	—	—		—	In addition there may be in this system up to 2 Program Units and a Gamma 300 Electronic Calculator, each with a certain number of storage positions.
IBM 1620	1959		Magnetic Cores: 20,000 signed dec. digits.	Machine cycle time 20 μs.	—	—	—	—	—	—	—	—	—

Table IV—OPERATIONAL FEATURES

Name	Pulse Repetition Rate	Scale	Word Length	Instructions per word	Address	Mode	Modifier, Index or B-Registers	Point	Remarks
High-Speed Scientific Computers and Data Processing Systems									
FERRANTI ATLAS	—	Binary.	48 bits.	1	1-address, but each instruction can also specify 2 modifiers.	Parallel.	128	Fixed and Floating.	Fully transistorised. Floating point addition in 1·2 μs.; overlapping with B-instructions.
IBM 7030 (STRETCH type Computer).	—	Binary with complete mixed radix working.	64 bits + 8 bits for checking (but with a further 10 checking bits in disc transfers)* or variable field length with no word boundaries.	Usually 2 (maybe 1).	1 or 2-address.	Parallel, or Serial.	16 (but this can be increased by a special instruction).	Fixed and Floating	* But instructions can work on variable fields. The effective speed of this machine is considerably increased by the use of a 4-stage instruction look ahead feature. Several storage references may be made at the same time through consecutive addresses being in separate storage units.
High-Speed Scientific Computers									
IBM 7090	5 Mc/s.	Binary.	36 bits.	1	1-address.	Parallel.	3	Fixed and Floating.	Completely compatible with the 709, but 6·3 times faster.
ELLIOTT 502	—	Binary.	20 bits.	1	1-address.	Parallel.	3 (effectively any Store Location).	Fixed.	Fully transistorised. Short word working for real-time applications. Extremely fast arithmetic operations within the 1 μs. store cycle on additions, etc.
ELLIOTT 503	—	Binary.	39 bits.	2	1-address.	Parallel.	Any of the magnetic core registers may be used as a B-register, i.e. 4096 or 8192.	Fixed and Floating.	The arithmetic unit is exceptionally fast, it can perform over two million operations per sec. Multi-length programming facilities will be available for handling both fixed-point and floating-point numbers, up to a maximum word of about 40,000 bits.
ENGLISH ELECTRIC KDF 9	—	Binary.	Basically 48 bits (operations can be on 24, 48 or 96 bit words).	Up to 6.	Variable.	Parallel.	15	Fixed and Floating.	Fully transistorised. Very fast arithmetic operations. Nesting-type working stores and variable length instructions greatly reduce program storage space and simplify programming.
Data Processing Systems with One Control Unit									
(i) *with automatic time-sharing features*									
AEI 1010	—	Binary.	44 bits (some operations on 13-bit numbers).	2 both individually addressable.	1-address.	Parallel.	8	Fixed and Floating.	Fully transistorised.
FERRANTI ORION	½ Mc/s.	Binary.	48 bits.	1	3 or modified 2-address.	Parallel.	63 per program, but any core store register may be used indirectly.	Fixed (Floating an optional extra).	Fully transistorised. Special facilities are provided for packing more than one item into a word, or for extracting such items from a word. See *Data Processing*, 2 (2), 114–121, April/June 1960.
LEO III	—	Any radix up to hexadecimal, including mixed radices.	40 bits (5 characters or 10 digits) +2 check bits +2 sign bits.	2	1-address.	Parallel.	12	Fixed and Floating.	—

Data Processing Systems with One Control Unit (contd.)

(i) *with automatic time-sharing features* (contd.)

IBM 7070	— —	Binary Coded Decimal (Self-checking code).	10 digits and sign, or 5 alpha characters.	1 (10 digits per instruction).	1-address.	Parallel by bit, Serial by digit.	99	Fixed and Floating.	Fully transistorised. Arithmetic and logical operations may be freely performed on any part of a word as specified in an instruction.
IBM 7080	—	7-bit parity checked Alphameric code.	Variable.	5 characters per instruction.	1-address.	Parallel by bit, Serial by digit.	Indirect Addressing available.	Fixed.	This system is the transistorised development of the IBM 705 with the addition of 7070 and 7090 features, i.e. the Automatic Priority Processing and the larger magnetic core store.
EMIDEC 2400	1 Mc/s.	Binary.	(i) For binary data, 34 bits + sign. (ii) For alpha-numeric data, variable up to 15 words (of 36 bits each) each word containing 6 characters of 6 bits each.	1 (single instructions may refer to multiwords).	2-address (one refers to the high-speed and one to the random access store).	Parallel.	Any of the 64 Diode-Capacitor Stores.	Fixed (Floating by Programme).	Solid state elements used throughout. Project initiated by the NRDC.
NCR 315	167 Kc/s.	Binary Coded Decimal.	Variable from 3 dec. digits, or 2 alpha characters (i.e. 12 bits + 1 parity bit) up to 24 dec. digits or 16 alpha characters.	24 bits or 48 bits.	Variable, 1- or 2-address.	Parallel by 12 bits, (i.e. minimum length word).	32 (18 bits).	Fixed.	Fully transistorised. Built-in macro instructions; automonitoring. 32 special registers for peripheral condition branches.
ENGLISH ELECTRIC KDP 10	—	Binary Coded Alpha-Numeric (self-checking code).	Variable, from one character upwards.	8 characters per instruction.	2-address.	Serial by character, Parallel by bit.*	7	Fixed.	* Data can be transferred to and from magnetic core stores in parallel groups of 4 characters. Fully transistorized. See *Data Processing*, **2** (1), 54–57, January, March 1960.
ICT 1301	1 Mc/s.	Binary Coded Decimal.	11 dec. + sign (4 bits/digit) or 6 alpha characters.	2 (instructions are obeyed in pairs in sequence, being called up together).	1-address.	Serial/ Parallel.*	—	Fixed (sub-routines for floating point).	* Transfers between the magnetic core store and the arithmetic unit are made in parallel mode along a transmission path consisting of 48 lines, i.e. parallel by word. Fully transistorised. All wrapped connections. Printed wiring.
(ii) *without automatic time-sharing features*									
EMIDEC 1100	100 Kc/s.	Binary.	36 bits.	1	2-address.	Parallel, but partly serial to peripheral units.	7	Fixed.	Fully transistorized. First installation in 1960.
STANTEC Computing System	128 Kc/s.	Binary.	32 bits + sign.	1	1, 1 + 1 or 2-address.	Serial.	22 (i.e. 12 registers + 2 accumulators + 3 constants + 5 input channels can all be used to modify orders giving the equivalent facilities of a large number of B-registers).	Fixed (Floating Point is programmed).	This system consists basically of the STANTEC-ZEBRA computer with peripheral units added. It still uses micro-operation instructions.

Table IV—OPERATIONAL FEATURES—*continued*

Name	Pulse Repetition Rate	Scale	Word Length	Instructions per word	Address	Mode	Modifier, Index or B-Registers	Point	Remarks
Data Processing Systems with One Control Unit (contd.)									
(ii) *without automatic time-sharing features* (contd.)									
IBM 1401	—	Binary Coded Alphameric.	Variable (8 bits/ character).	1 (Instruction length is variable; minimum 1, maximum 8).	2-address.	Serial by character, Parallel by bit.	3	Fixed.	Fully transistorised. High input/ output speeds, but normal processing. Can be used as an ancillary computer to a larger IBM system.
Data Processing System with more than one Control Unit									
BULL GAMMA 60	—	Binary or Binary Coded Decimal.	1 catena may contain either: (i) 24 bits. (ii) 6 dec. digits. (iii) 4 alpha-numeric characters.	1	Up to 3-address.	Parallel.	Variable number, but at least one for every automous unit.	Fixed and Floating.	See *Data Processing*, **2** (1), 26–31, January/March 1960.
Smaller Systems Announced from 1959 onwards									
(i) *with automatic time-sharing features*									
NATIONAL–ELLIOTT 802/803	167 Kc/s.	Binary	(i) 33 bits. (ii) 39 bits.	2	1-address.	Serial.	1020 or 4092, i.e. any of the magnetic core registers.	Fixed (Floating by sub-routine or extra unit).	803 is fully transistorised. General purpose, but originally designed for use in Process Control.
(ii) *Without automatic time-sharing features*									
BULL 300 DP Series	300 cycles/min.	Binary Coded Decimal	12 dec. digits each one of which is separately accessible.	3	1-address.	Serial by character, Parallel by bit.	—	—	All units in this system are synchronised to 300 cycles/min.
IBM 1620	—	Binary Coded Decimal.	Variable, 6 bits/ digit, or 12 bits/ character (or 2 digits/character).	12 digits for instruction length.	2-address (add-to-memory).	Serial by character, Parallel by bit.	—	Fixed (with Floating Point Routines).	Fully transistorised. Immediate addressing facility.

The contributions from Dr. Booth and the representatives of the manufacturers together with the general discussion will be published in the next issue of the *Bulletin*.

REGIONAL BRANCH NEWS

BRISTOL

The first meeting of the winter series of lectures was held on 28 September, when Mr. E. Russell Boardman of *ICT Ltd.* addressed a meeting on the subject "Computers for Beginners." An audience of 36 attended and enjoyed an interesting introduction to the subject.

The Bristol Branch is planning to hold a symposium entitled "The Computer Co-operative." The symposium is being arranged to cover organisational, financial and operational aspects of a computing or data processing installation owned and operated by a group of member firms on a non-profit-making basis.

The symposium will be held in Bristol on 28 March 1961, and will be open to those outside the Branch. Further details may be obtained from the Branch Secretary.

LEICESTER

The first meeting in the 1960–61 calendar of the Leicester branch was held on 20 October when Mr. Wragg of *Boots Pure Drug Co. Ltd.*, spoke on "Theory *v.* Practice."

The decision to install a large data processing installation at the company's central offices in Nottingham was made in order primarily to supply more selective, additional, and quicker information to management about the movement of the Company's vast inventory. The need for this had long been apparent, and in fact it had been hoped to open the computing centre a year previously, but delays in delivery had resulted in the work beginning just seven weeks before the meeting.

The data employed by the system originated from retail branch orders. Ideally, the system should have started at the point of sale of goods in the Retail branches, but there were many major obstacles to this.

Special order books had been prepared, which included the most commonly needed items. By aligning a card with each page of the order book, up to 45 items could be indicated with a soft pencil. The cards were posted to Nottingham where the marks were sensed and corresponding holes punched for input to the computer.

Other less popular items were ordered by using a four letter code, the last letter of which was for checking purposes. The proportion rejected by the computer as containing impossible codes was of the order of 1%, and would tend to rise as the assistants responsible for making out the orders grew more experienced. It was believed that familiarity with the system dispelled the initial painstaking approach. The two most prevalent mistakes when ordering by order cards, was to mark a wrong page or a wrong line.

At the data processing centre the branch orders were employed in conjunction with master stock and accounts files to produce invoices, stock reports, details of goods not supplied and outstanding, and other records.

Emidec had been found to be entirely reliable, although some trouble had been experienced with peripheral equipment. A related difficulty was that the time required to punch paper tape for items not in the specially prepared stock books was much in excess of the estimate, due to the difference between punching from type and punching from handwriting.

The scheme was first tried on a sample of 50 branches, and was now used by all 1,300 branches, for all goods from the photographic warehouse, which was one of nine. It was planned to extend the system to the other warehouses in turn.

MANCHESTER

The Branch held its Annual General Meeting followed by the first Branch Meeting of 1960–61 in the Manchester University Computing Machine Laboratory.

Dr. C. B. Hazelgrove, who becomes Branch Chairman for 1960–61, explained the features of the Mercury and some of the features of the Muse (or Atlas) that was under construction. This was followed by a most informative demonstration of the powers of the Mercury and most members found the special equipment used for graphical display particularly interesting. The members also had the pleasant surprise of being shown round the laboratory which used to contain the Mark I but which is now being used for the Muse which is being built there.

DEUCE USERS' COLLOQUIUM ON BUSINESS APPLICATIONS

The seventh DEUCE Users' Colloquium, on "Business Applications," was held on 4 and 5 October 1960, at the Russell Hotel.

The papers covered a wide range of topics and provided a programme which was perhaps a little heavy for the one and a half days allotted. The subjects were rather outside the most usual fields of DEUCE activity, and the lively discussion owed a good deal to the innovation of inviting a small number of people from outside the immediate family.

About 100 people attended on each day. The chair was taken by R. H. Tizard of Churchill College, Cambridge.

Session 1. Operational Research

The colloquium opened with a paper by F. D. Robinson of *English Electric Company*, Central Computing Service. DEUCE will shortly start being used to help with stock control

in one of the divisions of Stafford works. The paper described a simulation study using the computer to assist in designing and testing the proposed method of working. The proposed system will allow more frequent reviews of stock investment, in a rapidly changing environment, than would be possible without a computer.

J. E. Nicholls of *UKAEA*, Capenhurst, described the use of a mathematical model to assist in the control of a large gaseous diffusion plant. The model is used to give indications of the future behaviour of the plant. Any large deviations from these are immediately investigated for abnormalities in the plant, which in some cases might otherwise have remained undetected for several weeks until the output rate of the plant was affected.

Session 2. Linear Programming

In the second session, D. J. Flower of *English Electric Company*, London Computing Service, gave a survey of DEUCE linear programming programs including recent developments in integer solutions and quadratic programming.

A paper on the application of linear programming to refinery scheduling, originally prepared by W. J. Newby and R. J. Deam of *British Petroleum* for the Institute of Petroleum, was presented by P. B. Coaker and P. V. Slee. Some striking examples were given of the methods and effects of applying the results obtained. The whole of the result matrix was printed, rather than merely the final solution and partial costs; the internal coefficients could be used, possibly at a refinery remote from the computer centre, to predict the effect of some proposed change in operation upon all the quantities which it might affect.

U. J. Knight and I. J. Whitting of *CEGB* described some of their applications of linear programming to the planning and operation of electricity supply systems. The planning of a supply network between a number of points of supply and demand, subject to requirements for protection against breakdown of individual lines, involved obtaining integral solutions to a general L.P. problem.

The scheduling of generating plant maintenance to minimise the extra cost of using alternative, less efficient, plant, and the geographical distribution of a specified set of stations to minimise transmission and fuel transportation costs had both been ingeniously set up as transportation problems and solved on the computer.

Dr. S. Vajda opened the discussion, which was mainly concerned with techniques and led to some useful exchanges of information. It was generally agreed that more work was needed before methods for obtaining integral solutions could be regarded as entirely dependable.

Sessions 3 and 4. Production Control and Payroll

The second day started with contributions from *Short and Harlands* on their production control system. R. Cordner discussed requirements in controlling production, particularly in intermittent production with low repetition rate, and described the progress which had been made towards meeting them. T. J. Reid described in more detail experience of one year's operation of the system, and A. M. McNaghten discussed techniques of data preparation.

T. A. Robinson presented a paper on the well-known *Job White* application, in which all the working documents for the main production processes of a small textile manufacturing firm are produced in a short weekly run on a service computer. He referred to recent and proposed extensions of the system to cover such activities as costing and production planning.

R. W. Northwood described the history and development of the payroll system at *English Electric* Stafford Works. The 4,800 staff are already being paid by computer and the 5,200 hourly payroll will be in the system by March 1961. Reference was made to other proposed applications for example in stock control.

C. H. Marks of the Ministry of Aviation opened an extremely lively discussion which broke out again at the end of the colloquium.

Session 5. Large-Scale Statistical Processing

S. Nordbotten of the Central Bureau of Statistics of Norway was welcomed as the first person from overseas to come to a colloquium. His paper described a number of applications in general terms and the processing of overseas trade statistics in more detail. Some general comments were made on the management and operation of computers, and a sketch was given of the type of system which might be needed for statistical work in the future.

A paper by H. W. Emery of the Ministry of Agriculture, Fisheries and Food briefly described the current processing of agricultural census returns on a plain DEUCE Mk. IIA, and outlined a plan for extending the equipment in several stages as further, more complex jobs were taken on. In this way, the complexities of the equipment as well as of the jobs need only be gradually assimilated, though it might involve some re-programming of the old jobs for the new equipment.

D. H. Rees of Rothamsted Experimental Station opened a discussion which covered Mr. Nordbotten's ideas on computer operation and Mr. Emery's theory of evolution as well as such statistical topics as techniques for testing credibility, correcting errors in data and checking results.

Session 6. Data Processing

In the final session, W. F. K. Warren of *UKAEA*, Capenhurst, described the system for collecting detailed data on plant behaviour and performance and analysing this in order to detect and forecast trends in performance.

A. Gilmour of *English Electric*, Central Computing Service, described three applications in railway operation, planning the redistribution of empty coal trucks, an exercise in the automatic compilation of railway timetables, and the processing of hundreds of local daily statements about numbers of empty trucks in order to improve their accuracy.

E. A. Newman of *NPL* opened the discussion on Session 6 and also contributed to the final general discussion. D. V. Blake, also of *NPL*, outlined his investigations into the preparation of school timetables.

W. P. Mirtle of *English Electric*, Stafford Works, added fuel to the controversy on production control, and discussion ranged on whether production control was theoretically possible, whether faster computers would do the job better, what the job was, who should be in charge of its operation, whether it was not much easier than partial differential equations, whether mathematicians and research engineers should be let within a mile of it.

Eventually Mr. Tizard managed to control the controllers and the meeting was brought to a conclusion.

G. M. D.

BOOK REVIEWS

Mathematical Methods for Digital Computers

Edited by A. Ralston and H. S. Wilf, 1960; 293 pages. (New York: *John Wiley & Sons Inc.;* London: *Chapman & Hall Ltd.*, 72s. 0d.)

The development of high speed computers has led to a resurgence of interest in numerical analysis, and has undoubtedly been responsible for the appearance in recent years of a steady stream of books on that subject. In spite of this, few of these books have given a treatment that is computer-oriented, either because the authors had gained their experience on desk machines or had prepared their material before the full impact of computers had made itself felt. This book does something to redress the balance, though it is not strictly a textbook on numerical analysis.

Each of its twenty-six chapters has been written by a research worker who is active in the appropriate field, and together they cover most of the branches of numerical analysis in which high speed computers are being exploited. There are six main sections covering the computation of elementary functions, matrices and linear equations, ordinary differential equations, partial differential equations, statistics and a final section covering the solution of polynomial equations, numerical quadrature, Fourier analysis, linear programming and network analysis. Having regard to the great variety of the subject-matter and the number of contributors a reasonable continuity of presentation has been achieved, though it is a little disconcerting to be given a rather painstaking definition of an eigenvalue and an eigenvector in Chapter 18 when a considerable knowledge of the eigenproblem has been assumed in most of the earlier chapters. A standard format has been adopted for most of the chapters, beginning with a concise formulation of the problem followed by a mathematical discussion and concluding with a fairly detailed discussion of the computing procedure. In each case the procedure is illustrated by a flow chart presented in a standard form, usually a small sample problem, a discussion of the memory requirements and finally an estimate of the running time in terms of the number of arithmetic operations involved.

The allocation of space to the various topics reflects fairly accurately the division of the research effort in the United States in the last decade. It is interesting to note that more than half of the book is concerned with matrix problems since this forms the main subject-matter not only of the section on matrices and linear equations but also of a good part of the sections on partial differential equations, statistics and linear programming. A particularly good coverage is given to the solution of the finite difference equations derived from elliptic and parabolic partial differential equations.

It is inevitable that a book which has been produced in this way should be somewhat lacking in character, but this is probably more noticeable to the reviewer who must read it straight through, than to the ordinary user. In spite of the rather critical frame of mind that this induced, I found myself quite impressed and feel sure that it will prove valuable as a reference to a fairly wide class of readers. The provision of extensive references to papers published in the last ten years should make it particularly useful to those who are starting research in numerical analysis.

J. H. Wilkinson

Nomography

By Alexander S. Levens, 2nd Edition 1959; 296 pages. (London: *Chapman & Hall Ltd.*, 68s. 0d.)

This book demonstrates that a technical book can be informative, technical and readable at the same time. Professor Levens leads the newcomer gently but firmly through Nomography from simple functional scales and alignment charts to the new chapters of the book on circular nomograms and projective transformations.

The new chapters are as clear and concise as the revised chapters of the previous edition. The Appendix with its excellent examples, which cover a wide field of applications from nuclear shielding nomograms to those for evaluating the syrup strength of tinning peaches, is a very useful feature and worthy of note by others. The "Summary of Type Forms" addition preceding the Appendix is also helpful for fast reference.

In all, the book is to be recommended for those wishing to apply nomographical methods to solving the infinite variety of problems which can arise in science and engineering. These methods can, as Professor Levens shows us so admirably, be applied to a far greater range of problems than is usually imagined.

Design of Transistorised Circuits for Digital Computers

By A. I. Pressman, 1959; 316 pages. (New York: *John F. Rider Inc.*, \$9.95; London: *Chapman & Hall Ltd.*, 80s. 0d.)

The first few chapters of this book provide a well arranged introduction to the design of transistorised logical elements for digital computers.

The author opens with a section on the logical properties required of the elementary computer bricks and the rules for the combination of these bricks. A short description of transistor and diode characteristics then leads into the main part of the book which gives a fairly complete catalogue of the various systems of logical bricks that are in use.

One always hopes to see in a book such as this a section summarising the criteria by which the various techniques can be critically assessed. There is no such section in this book, although some of the relevant information is given at the end of the descriptive chapters. As a result this book is not entirely adequate for the uninitiated reader.

Towards the end of the book some detailed designs are worked out in which rather dogmatic emphasis is laid on the use of worst case design methods and large and somewhat arbitrary factors of safety. Of course, the conservatism implied by these methods is all very laudable and certainly leads to computers which work, but one feels that it should have been mentioned that statistical methods can be applied to the calculation of the effects of component tolerances. Such methods give a more accurate result and in many cases, permit the performances of the circuits to be improved at a negligible cost in the factory rejection of complete circuit units.

Apart from the above rather pedantic criticisms this book can be well recommended to those concerned in the engineering design of digital computers.

G. G. Scarrott

Digital Computer Principles

By W. C. Irwin, 1960; 321 pages. (London: *D. Van Nostrand Co. Ltd.*, 51s. 0d.)

"Digital Computer Principles" has been developed from a course of lectures given to the personnel of the Electronics Division, *National Cash Register Company* of Dayton, Ohio. It is written for the general interest of beginners with no previous acquaintance with computers, electronics or mathematics, who wish to know something about the logical design of a general purpose synchronous computer. It is not claimed that the treatment is comprehensive and the book might have been called "Some Thoughts on the Logical Design of a General Purpose Computer." The author hopes it will assist students to enjoy a wider literature.

The book begins with an analysis of the methods of computation, referring in particular to binary calculations. This is followed by an introduction to the methods of symbolic logic using several forms of hardware and the mechanisation of arithmetic. The section on external communication includes the usual devices, and discusses half-a-dozen binary type codes. Some space is devoted to programming in which the usual addressing systems are compared. The final chapters are devoted to error detection and correction, preventive maintenance, core logic and future trends.

There is a feeling that the author has not done justice to his lectures and in this sense the book is disappointing. In writing for beginners, a good digest would have produced a book of real value. If paper tape can take forms other than "narrow continuous," let the reader know about it. To say "it is customarily punched with rows of holes running crosswise" implies at least one alternative. It is then explained that six-holed tape is "sufficient to represent all the numerals and alphabetic characters, plus many special symbols." Why illustrate seven-hole tape and not mention parity? With nine pages (see index) devoted to flip-flops a description of a flip-flop in terms of hardware might have been included. A word on the connection between Gray's code and inverted binary would have helped to illustrate the build up of the code.

These comments do not imply lack of useful information. There are 42 chapters well filled with diagrams, printed in a pleasant style where the beginners will "discover many new ideas which are not similar to common experience."

L. T. G. Clarke

Introduction to Linear Programming

By W. W. Garvin, 1960; 281 pages. (New York: *McGraw-Hill Publishing Co. Ltd.*, 68s. 0d.)

It may be said at the outset that this is a good book, and that the reviewer's main objection is to the title. It is much more than an introduction, as will be seen from a brief description of its contents. Part I (five chapters) deals with the fundamental concepts, develops the Simplex Method, considers the dependence of the solution on the constants in the conditions, and discusses an application in the oil industry.

Part II (five chapters) is devoted to the transportation problem and some of its variants. The practical importance of these problems deserves a special treatment, and they are also simpler to solve. Because of this, electronic computers can cope with larger problems than in the general case, but this is not mentioned. The chapter on the "generalised transportation problem" treats a case whose discussion is rather neglected in other texts.

Part III (eight chapters) is called Special Methods, for lack of a better title to cover short-cuts when the variables have constant upper bounds, statistical linear programming (rather superficially), the computationally most convenient variant of the Simplex Method, the resolution of degeneracy (another computational aspect), an economic model, and duality. The latter subject is, once more, treated from the point of view of the practical man, and its central role in the theory of linear inequalities does not emerge. Charnes and Cooper's Warehouse problem is given as an example for yet another computational device, the "regrouping principle." At the end of chapters there are a few simple exercises, without solutions.

It is typical of all books on linear programming known to the reviewer that they cater mainly for readers who do their computations on paper, though the book under review contains a number of illuminating flow diagrams, which could well serve as a basis for computer programs. What we have in mind when we wish for further information can be illustrated by taking the case of degeneracy in the transportation problem. On page 102 we are told that degeneracy leading to the periodic recurrence of an earlier iterative step, and hence to a non-ending loop, "is just as rare for the transportation problem as it is rare for a general linear-programming problem." We are then referred to Chapter XIV for a device which makes sure that no such loop occurs. But this device is only mentioned in an exercise at the end of that chapter, and no remark is made to the effect that, in automatic computation, factors must have a numerical value rather than an algebraic symbol, and that the value of the factor involved here ought to be chosen so that its tending to zero is equivalent to rounding fractional numbers to the nearest integers. Incidentally, no case, practical or artificially constructed, is as yet known of a loop in a transportation problem. The computational embarrassment of degeneracy is due to another aspect of the most usual method for its solution.

On p. 116 it is correctly stated that the problem of allocating candidates to jobs is of transportation type, though highly degenerate. The Ford-Fulkerson method is suggested for its solution. The reviewer would have liked to see also a reference to Kuhn's so-called Hungarian Method, because Kuhn's paper in *Naval Research Logistics Quarterly*, **2**, p. 83 (1955), contains a flow diagram for automatic computation.

In the field selected by the author the book contains an admirably wide range of instruction and it is most readable. I have found only one misprint: the reference to the paper by Motzkin and Schoenberg on p. 26 should be [50], not [51]. The reader who is intrigued by the twisted lines shown on the dust-cover is referred (by the reviewer) to p. 127 for explanation.

S. Vajda

THE FERRANTI ARGUS PROCESS CONTROL COMPUTER

by T. A. Stones

In theory, with the attachment of the appropriate input and output devices, any general purpose digital computer could be used to control industrial processes—assuming it has sufficient capacity to hold the control program and is fast enough to control the process concerned. However, after a careful study of the special problems involved in process and sequence control, Ferranti Ltd. have incorporated several original features in the Argus computer which make it eminently suitable for this type of application.

In the first place it is advantageous for the computer to be able to select inputs and outputs in any order demanded by the program and not to have to deal with them in a fixed sequence. This has been achieved in Argus by allocating an address to each analogue input, to each word of packed digital (on/off) information and to each output destination. When one of these addresses is specified in an order using an appropriate function, information is read from, or sent to, the required location. Solid state selection and conversion devices enable input and output transfers to be performed in times comparable with the basic order times of the computer so that the machine does not need to wait for information to become available.

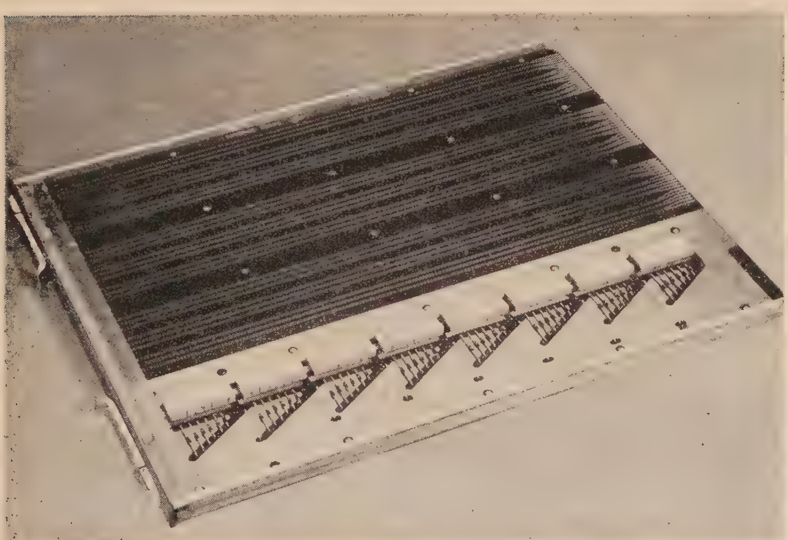
The normal analogue signals present on industrial processes such as chemical plants are accurate to about 1%. It is thus wasteful to use a computer with a normal word length to do operations on such information and the word length of Argus is 12 bits—corresponding to an accuracy of 1 part in 2,048. Special facilities have been built into the machine to facilitate double length working where this is considered necessary.

The form of the program store is another unusual feature of Argus. This is an inductive pegboard type of store which has very fast access and which eliminates the possibility of accidental changes to the program occurring whilst still allowing alterations to be made when they are required. The program store can hold either instructions or constants and can have 1,024, 2,048 or 4,096, 24-bit locations (plus a parity bit on each location).

The working store of the machine is a core store which can have 1,024, 2,048 or 3,072 12-bit locations (plus parity). The form of the storage in Argus, coupled with a 6-bit serial, 2-bit parallel mode enables Argus to perform operations very quickly. The time for addition, subtraction and most logical orders is 20 μ-sec, rounded multiplication takes 100 μ-sec and division 200 μ-sec. The equivalent operations on 24-bit numbers require double the above times and modification adds 20 μ-sec to any order.

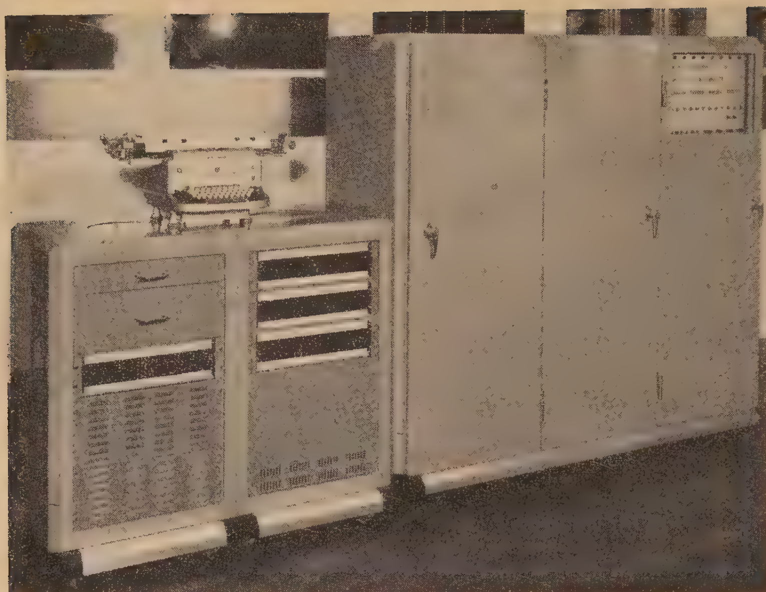
Two interrupt facilities are included in Argus. One is operated by a timer which is set to an appropriate period. After the set time has elapsed the computer leaves the master program at the completion of the order in progress and enters a special program called the Interrupt Routine. This will normally monitor critical input values and cause the appropriate corrective action to be taken. A link is set automatically when an interruption occurs so that the master program can be re-entered at the appropriate point. Counters can be set and reduced in the interrupt routine so that some functions need only be performed at intervals which are integral multiples of the basic interrupt period. The timer interrupt is an extremely valuable feature of a machine which is to be used for real time operations—the alternative being to examine a clock at regular intervals by program.

The second method of interruption in Argus is the Core



An Argus Program Tray.

A tray can hold 64 instructions, but this tray is not pegged up.



The Argus Computer with a typewriter and drive circuitry.

Store Interrupt facility which effectively enables part of the working store of the machine to be used as a buffer for an input and/or an output device, the amount of the store allocated for this purpose being at the discretion of the programmer. It enables information to be transferred into or out of the core store as soon as the appropriate input/output devices are ready for such transfers. Each transfer is initiated by a "not busy" signal from the device concerned and is not programmed—indeed transfers are autonomous with operation of the master program. Transfers can take place every 20 μ-sec and will only be held up for 20 μ-sec if the program requires access to the core store at the same time as the Core Store Interrupt.

Argus is thus seen to be an unusual computer and the above features, coupled with an extremely high standard of construction, make it ideal for a wide variety of process control applications. The basic computer, however, can only form part of a system involving a variety of input, output, storage and logging devices. Detailed studies of several specific applications have shown that, in terms of cost and therefore of equipment, the computer accounts for about half of a typical complete system.

Overseas Computer Journals

The British Computer Society has arrangements whereby members of certain overseas computer societies may subscribe through their local societies to its publications at reduced rates and reciprocal benefits are extended to BCS members.

The arrangements apply to individuals who are members of The Association for Computing Machinery resident in North America and members of L'Association Française de Calcul resident in France or Algeria. The rates applicable are as follows:

	A.C.M. members in North America	*A.F.A.C.L. members in France or Algeria*
The Computer Journal (four issues per year)	U.S. $5.00	NF. 21.50
The Computer Bulletin (four issues per year)	U.S. $3.00	NF. 13.00
Combined subscriptions for both publications	U.S. $7.50	NF. 32.50

Subscriptions should be sent to the secretary of the local society for onward remittance in bulk.

In return, individual members of The British Computer Society Limited resident in the British Isles may subscribe to the following overseas publications at the reduced rates shown:

	Per year
Journal of The Association for Computing Machinery: Communications of the A.C.M.	£1 9 0
Chiffres (Journal of A.F.C.A.L)	£1 14 6

Subscriptions from members resident in the British Isles should be forwarded to The Assistant Secretary, The British Computer Society Limited, Finsbury Court, Finsbury Pavement, London E.C.2.

The above rates are based on rates of exchange ruling at 30 November 1960.

THE ENGLISH ELECTRIC KDF 9 COMPUTER SYSTEM

by G. M. Davis

The KDF 9 computer system was entirely designed and is being built at the *English Electric Company*, Data Processing and Control Systems Division, Kidsgrove, Stoke-on-Trent. The main design objectives were (*a*) very high speed of operation, (*b*) ease and economy of programming and (*c*) full facilities for general data processing applications.

The high speed of operation is achieved in the first instance by logic and circuit design techniques which provide, for example, a multiplication time of 14 microsec and a core store cycle time of 6 microsec, while using well-tried components and only one core per bit.

Further speed is achieved by the arrangement of the arithmetic registers in a nesting store; combined with a novel form of variable-length instruction, this provides a startling economy in program storage space. As examples, a simultaneous linear equations routine occupies 36 words and solves 100 equations in 10 seconds; a simple sorting routine occupies 35 words and sorts 2,000 variable-length items of average length four words in less than three seconds.

There are optional provisions for running up to four independent programs at once and for anticipating main store transfers in order to increase effective speed. Peripheral transfers are autonomous, and any number can operate simultaneously subject to a maximum total transfer rate of 1·33 million characters per second. The system uses only transistor circuits made up on printed wiring boards and ferrite cores for the main internal store. Additional storage and peripheral units can be fitted with very little trouble as work load increases. A wide range of peripheral units is available, including all those developed for the KDP 10 Data Processing System.

Storage System

KDF 9 has a main internal core store with a cycle time of 6 microsec. It is assembled in units of 4,096 48-bit words and any existing installation is readily expansible up to a maximum of 32,768 words.

Three further very rapid access stores provide working space for (*a*) current operation, (*b*) entering and leaving subroutines and (*c*) instruction modification and counting. The first two are "nesting stores," the last consists of fifteen 48-bit registers known as "Q-stores."

A Nesting Store

Probably the most distinctive single feature of the KDF 9 is the use of a "nesting store" technique in conjunction with a modular instruction format.

A "nesting store" is in effect a series of registers holding a column of items of data, with the rule that an incoming item joins the column at the top and causes all the items already present to move down one place. Similarly, an item can be transferred out of the column only from the top, and when this happens all the remaining items move up one place. A "place" in this sense may be either one or two single-length locations, since items transferred in or out may be either single or double length.

Most arithmetic and other operations in the KDF 9 take place in the current operation nesting store, the operands being found and the result stored in the top few locations; the exact number of locations actively involved varies from one to four depending on the operation being performed. In single-length addition, for example, the contents of the top two locations are added, the sum is stored in the top location, and any other items, from the third location onward, are moved up one place, i.e. into the second location onward; it will be noted that the operands are not normally retained in the nesting store after the operation. In an operation on one operand, such as negation, the result replaces the operand in the top location and any items of data in the remaining locations are not moved.

As an example of nesting store operation, consider the caulculation $(a + b)(c + de) = f$, where the letters refer to the contents of main store locations. The sequence of operations (with corresponding nesting store contents) might be set out at length as follows, where $N1$ represent the contents of the top (most accessible) location.

	$N1$	$N2$	$N3$	$N4$
(1) fetch a	a			
(2) fetch b	b	a		
(3) add	$a + b$			
(4) fetch c	c	$a + b$		
(5) fetch d	d	c	$a + b$	
(6) fetch e	e	d	c	$a + b$
(7) multiply	de	c	$a + b$	
(8) add	$c + de$	$a + b$		
(9) multiply	$(a + b)(c + de)$			
(10) store in f				

The operations involved, 5 fetches, 1 store, 2 additions and 2 multiplications are the irreducible minimum for the calculation. This enables an instruction code to be used which is the most economical possible and which avoids the specification and execution of superfluous transfers. Since the code refers directly to the "atoms" of a data processing procedure, it forms a convenient basis for the analysis of procedures expressed in a problem-oriented pseudocode, and the production of an extremely efficient final program.

Arithmetic Operations

A wide range of arithmetic operations is provided, including double-length floating and fixed-point, and half-length working using every half-word of the main store. There are also operations for conversion between binary and any single-word, mixed-radix representation in 6-bit characters. Typical speeds of operation are:

Addition (fixed point)	1 microsec
Addition (floating point)	5 microsec (minimum)
	10 microsec (maximum)
Multiplication (fixed or floating)	Up to 14 microsec
Mixed radix conversion	50–150 microsec

These times include any necessary nesting operations but not any main store transfers, since these occur as separate operations.

Word Layout (data)

The standard word of 48 binary digits may be treated in various ways:

For data 1 fixed-point 48-bit number.
1 floating-point number with 8-bit exponent and 40-bit mantissa.
2 fixed-point 24-bit numbers.
8 6-bit coded characters.
½ double-length fixed-point number.
½ double-length floating-point number.

Instruction Code

For instructions, the 48-bit word is divided into six "syllables" of 8-bits each. An instruction may occupy one, two or three syllables.

The one-syllable instructions include most of those concerned solely with operations in the nesting store; as well as arithmetic and logical operations, these include operations for organising the course of a program and for manipulating and rearranging the top few items of data in the nesting store.

The three-syllable instructions are those directly specifying a main store address; that is, transfers to or from the main store and conditional and unconditional jump operations.

The two-syllable instructions specify various ranges of operations including peripheral transfers, transfers to or from Q-stores, shifting, manipulating data stored more than one item to a word and indirect addressing of the main store.

As an illustration of the economy and speed of operation, the small example given above would require 3¾ words of instructions and would be completed in 66 microsec.

Address Modification and Counting

There are fifteen high-speed addressable registers called Q-stores. These may be used for address modification and, counting, in which case they hold three separate numbers, a modifier, an increment and a counter. Each main store transfer instruction specifies a Q-store, the modifier part of which is added to the main address before execution; the instruction may also specify that after the transfer the increment is added to the modifier and one is subtracted from the counter. The three parts of a Q-store are separately addressable.

Subroutine Jump Nesting Store

As well as the current operation store, there is a nesting store of eight 18-bit registers used in entering and leaving subroutines. On entering a subroutine, the current instruction location is stored in the top register, nesting down the previous contents; on leaving the subroutine, control is transferred to the location whose address is in the top location, and the other contents are nested up. In this way, closed subroutines of up to eighth order can be handled very simply; the subroutine jump nesting store is also used in other program control operations.

Peripheral Operations

A transfer of data between the main store and a peripheral device, such as a magnetic tape unit or a punched card reader, is initiated by an instruction which specifies the starting main store location, the number of words to be transferred (or the maximum number for an inward transfer), the identity of the peripheral unit and the operation to be performed (e.g. read, write, read backwards from tape). The transfer then proceeds autonomously, and the area of main store concerned remains inaccessible to any other operation until completion of the transfer and any automatic checks involved.

Any number of peripheral devices can be connected into the system, and can operate simultaneously subject to a maximum total transfer rate of 1·33 million characters per second.

Peripheral Units

The KDP 10 peripheral units will be available with KDF 9, including the range of off-line transcribers. Other units including faster magnetic tape units will also be available. The relevant KDP 10 units are:

Magnetic tape units reading and writing 33,333 or 66,666 characters per second with special checking features and rapid start-stop operation.
Punched paper tape reader, 1,000 characters per second.
Electro-mechanical printer—600 lines per minute of 120 alpha-numeric characters (on-line or off-line from magnetic tape).
Xeronic printer—3,000 lines per minute of 120 characters (off-line from magnetic tape).
Paper tape punch—300 characters per second.
Monitor printer typewriter—10 characters per second (with monitor paper tape punch).
Punched card reader—400 cards per minute (on-line or off-line to magnetic tape).
Card punch—150 cards per minute (on-line or off-line from magnetic tape).

Time-sharing Among Programs

The system can handle up to four completely independent programs at one time; the programs will have been given a priority rating by the operator, and each program allocated its own area of main store and set of peripheral devices.

The top priority program continues to operate until it is held up, for example by a peripheral transfer, when the second priority program takes over. If a program attempts to use equipment not allocated to it, it is interrupted, a failure message is printed, and control is transferred to another program.

The allocation of equipment to programs, program interruptions and failure indications are handled by a permanently stored Supervisory Routine.

NEWS FROM MANUFACTURERS

In the Constellation of Orion

A new language for writing programs of instructions for digital computers has been developed by Ferranti commercial data processing experts.

Called NEBULA, it will be of great value to business users of these machines because it is based on readily understood English words and phrases, together with punctuation marks and other familiar signs, instead of on the specialised code symbols which are normally used for programming.

NEBULA has been devised after a long and intensive study of other automatic programming languages, or "autocodes" as they are sometimes called, which have been proposed in the past. It is claimed to be simpler, more flexible and capable of greater extension than these previous systems.

Because NEBULA takes the form of statements approximating to normal English phrases it is suitable for business users unfamiliar with conventional programming methods, but it can also be rendered into a more abbreviated and symbolic form which may be preferable to experienced programmers.

An instruction relating to insurance data processing, when written in the familiar English form, would read:

If New Policy: Copy Policy To New Main File.

In the abbreviated form this instruction would be written as a sequence of letters, numerals and other symbols.

Such instructions, either in the familiar language form or in the abbreviated form, are tapped out directly on a keyboard by an operator and so transferred to punched tape or cards, whichever medium is used for programming purposes. When this program of instructions is fed into the computer it is automatically translated into the "machine language" which the computer "understands."

The words and symbols used for NEBULA are comparable with Basic English, in that the instructions for programming must be built up from a restricted word list. When the computer user, however, wishes to compile his own list of words for describing data and sequences of operations in the program, provision is made in the computer that the "translation" process will "recognise" these words. For example, French, German or any other language can be used as the basis for NEBULA.

Why NEBULA as a name? It is derived from the full title of Natural Electronic Business Language. At the same time there is a connection with one of the Company's latest high-speed computers, the ORION, which will be used mostly for business applications. Amateur astronomers do not need to be reminded that there is a Great Nebula in the constellation of Orion after which this computer is named.

Univac Step and Solid-State-80

The Univac Computer Division of *Remington Rand Ltd.* have recently announced a new name in the Univac Computer range. This is the STEP (*S*imple *T*ransition to *E*lectronic *P*rocessing). This machine is designed on the building block principle. Thus, a customer with a small volume of business (computer-wise) and relatively simple procedures can put his work on a STEP System with its 24,000 digits of memory storage and add to this capacity in increments of 2,000 digits as his business expands and his procedures diversify.

The table shows the relationship between the STEP and the Univac Solid-State-80, together with the principal characteristics of each system.

	Minimum Specification	*Maximum Specification*
Central Processor	24,000 digits main storage 3 Arithmetic registers Full computing facilities except no multiply or divide circuits Fully buffered for input/output	50,000 digits main storage 3 Arithmetic registers Full computing facilities with multiply and divide circuits Fully buffered for input/output 3 Index registers
Highspeed Reader	450 cards per minute 2 read stations 1 output stacker	600 cards per minute 2 read stations 3 output stackers
Punch Unit	150 cards per minute 1 punch station 1 output stacker	150 cards per minute 1 pre-punch read station 1 punch station 1 post-punch read station 2 output stackers
Highspeed Printer (On-line)	600 lines per minute 100 characters per line Variable spacing	600 lines per minute 130 characters per line Variable spacing
*Tape/Randex Synchroniser	Storage for 1 block (100 alpha/numeric words) of data Control circuitry for 10 Tape/Randex Units	
*Magnetic Tape Units (Uniservo II) (max. 10)	Mylar or metallic tape 100 alpha-numeric 10 character words per block 4,800 blocks per tape (mylar) 3,000 blocks (metallic) Read/write speed 25,000 characters per second	
*Randex Drums (max 10 Units)	24,000,000 digits per unit Access time 200 milli-seconds normal	
Card Punching Printer	Up to 150 cards per minute punched and printed both sides 1 punch station 1 post-punch Read station 2 Print stations Up to 26 lines printing (between punching rows) per card, 70 cols. per line 3 Output stackers	

* These Units can be used with the STEP System at its minimum specification or the USS-80 at its maximum specification stage, or at any point in between.

Notes on the Submission of Papers

Communications. Papers submitted for publication should be sent to one of the honorary editors: E. N. Mutch, The University Mathematical Laboratory, Corn Exchange Street, Cambridge, *or* H. W. Gearing, c/o The Metal Box Company Ltd., 37 Baker Street, London, W.1. They will then be sent to members of the Editorial Board who will advise on subjects within their particular experience. The author will be informed as soon as possible whether the paper has been accepted for publication, the date of the journal when it will probably appear, and of any modifications suggested by the referees.

General. Submission of a paper to the Editorial Board will be held to imply that it is an original article not previously published; that it has been cleared for publication so far as military or commercial secrecy is concerned; that it is not under consideration for publication elsewhere; and that if accepted for *The Computer Journal* it will not be published elsewhere in the same form, in English or any other language, without the consent of one of the Editors.

Contributors who reside outside Great Britain are requested to nominate somebody in Great Britain willing to correct their proofs. Papers from such contributors should be accompanied by a statement of the number of reprints required.

Authors' names should be given without titles or degrees. Women are requested to give one Christian name in full to avoid confusion. The name and address of the laboratory or other institution where the work was performed should be given.

Typescripts should carry the name and address of the person to whom the proof of the paper is to be sent and should also give a shortened version of the paper's title, not exceeding forty-five letters and spaces in length, suitable for a running title in the published pages of the work.

Form of papers submitted for publication. The onus of preparing a paper in a form suitable for sending to press lies in the first place with the author. Proper attention to detail in the preparation of the typescript before it is sent to the Editors will shorten the time required for publication. Papers not in satisfactory form may have to be returned to the authors for revision.

Papers should be in double-spaced typing on one side of sheets of uniform size with large margins. A top copy and one carbon copy should be submitted. Each paper must be accompanied by a summary of its contents which will be printed immediately below the title at the beginning of the paper. Pages should be numbered consecutively in arabic.

Footnotes. These should be typed immediately below the line to which they refer. The sheet should be ruled in ink for its whole width above and below the footnote. Footnotes should be used sparingly and should be brief.

Tables. Each table should be numbered consecutively in arabic and should have a general heading typed at the top, as well as the necessary headings to columns, etc. Column headings must be sufficiently brief to permit convenient setting up in type. Careful attention should be paid to layout so as to avoid tables of excessive width; the printing area of the *Journal* page is 7″ × 9″, in two columns. Headings should be chosen so as to make the tables as far as possible comprehensible without reference to the text. Tables should not normally be included in the text but should be typed on separate sheets. More than one table may be included on a single sheet, but tables should not be split between sheets. Their approximate position in the text should be indicated in the margin of the text.

Mathematical formulae. These must be clearly written, avoiding symbols or arrangements which are difficult to set up.

Figures. Simple diagrams and flow-charts involving only a few lines may be set up in letterpress at the discretion of our printers. Directional arrows must be clearly indicated. Most diagrams will, however, require to be photographically reproduced.

Where a diagram involves curves, diagonal rules, or other detail which cannot be set up in type, it must be well drawn in indian ink and clearly lettered on plain white paper, Bristol board or faintly blue-lined paper. The diagram should be approximately twice the size of the finished block. The size limits for finished blocks are: *width*, single-column 3¼″, double-column 7″; *depth* 9″. Each diagram should be on a separate sheet, packed flat and bearing the author's name on the back.

For photographs, glossy prints are required; clips should not be used and care should be taken to avoid heavy pressure when writing on the backs.

Figures should be numbered consecutively. Legends should be so written that the figures are as far as possible comprehensible without reference to the text. The approximate position of the figures should be indicated in the margin of the text.

In cases of doubt, a rough draft should be sent to one of the honorary editors for a decision as to the best method of reproduction, before the fair copies are prepared.

References. These should be given in the text thus: Barnett and Robinson (1942), (Culbertson and Thomas, 1933); where a paper to be cited has more than two authors, the names of all the authors should be given when reference is first made, e.g. (Osborne, Mendel and Ferry, 1919); subsequent citations should appear thus (Osborne, *et al.*, 1919). Where more than one paper by the same authors has appeared in one year the reference should be given as follows: Osborne and Mendel (1914)*a*; Osborne and Mendel (1914*b*); or Osborne and Mendel (1914*a*, *b*); (Osborne and Mendel, 1914*a*, 1916; Barnett and Robinson, 1942). At the end of the paper references should be given in alphabetical order according to the names of the first authors of the publication quoted, names with prefixes being entered under the prefix, and should include the author's initials, year of publication, title of paper, the name of the journal, volume and first page number. References to books and monographs should include year of publication, the title and edition, town of publication and the name of the publisher. Examples:—

Crandall, S. H. (1954). "Numerical Treatment of a Fourth Order Parabolic Partial Differential Equation," *J. Assoc. Comp. Mach.*, Vol. 1, p. 111.

Royster, W. C., and Conte, S. D. (1956). "Convergence of Finite Difference Solutions to a Solution of the Equation of the Vibrating Rod," *Proc. Amer. Math. Soc.*, Vol. 7, p. 742.

Crandall, S. H. (1956). *Engineering Analysis, A Survey of Numerical Procedures.* New York: McGraw Hill Book Co.

Authors are asked to check their references for accuracy before submission of the paper.

Proofs. The authors are responsible for seeing that their typescripts are in final form for publication. Proofs are sent to authors in order that they may make sure that the paper has been correctly set up in type, and not that they may add new material or make corrections to the text. Otherwise increased printing charges are inevitable. Excessive alteration may have to be disallowed. The symbols used to indicate corrections should be those laid down in British Standard 1219: 1945; a shortened version is also published (B.S. 1219*c*: 1945, 1s. 6d.).

Reprints. Twenty-five reprints are supplied free of cost. Additional reprints may be purchased if the Editors are notified on the appropriate form when the proof of the paper is returned.

Editorial

STUDY GROUPS

One of the most valuable activities open to members of the Society is that of taking part in a Study Group. The emphasis should be on the word "activities." If a member has specialised computing experience he is in a position to contribute to a Study Group which deals with his own field.

A Study Group will no doubt keep a watchful eye on conferences, symposia and courses dealing with aspects of its own field of study. The *Bulletin* publishes details of courses from time to time but cannot hope to give readers advance information of all the useful meetings. Could a Study Group approach its local University or College of Technology if it feels the need for a course of lectures dealing with the background of its interests?

Study Group reports are available at the Society's offices for members to see. If the material is of current interest, the *Bulletin* endeavours to publish a progress report or appraisal: such an appraisal appears in this issue. The viewpoint of a group of members, however, is not necessarily accepted by others and the correspondence columns of the *Bulletin* are open to these other viewpoints within the limits of space.

SOCIETY AND COUNCIL NOTES

At their recent meetings, Council have been considering the functions and composition of their various Committees, aided by recommendations from the newly-formed Executive Committee.

The main functions of this Committee are to implement Council policy and thus relieve Council of day to day work, much of which was concerned with administration, to co-ordinate the work of Committees to avoid over-lapping and to give Committees more power to act within agreed policies without having to refer back continually to the full Council.

The members of the Executive Committee are D. W. Hooper (Chairman), E. E. Boyles and R. L. Michaelson (Vice-Presidents), E. C. Clear Hill (Honorary Secretary), H. W. Gearing (Honorary Treasurer), D. H. Rees and R. M. Paine. S. A. Tasker, the Society's Assistant Secretary, is Secretary to the Executive Committee.

The three principal functional Committees of Council used to cover meetings, publications and public relations. The Public Relations Committee has done a great deal of work over the past few years in making the Society's purpose known and in attracting a considerable amount of publicity for its activities, but its main task has been associated with the Society's conferences. The normal activities of the Society are not especially news-worthy to a wide press, and as there will be no conference this year Council have decided that the public relations aspect of the Society's activities should be looked after, for the time being, by the Executive Committee, until the 1962 conference demands more concentrated activity.

Wherever possible, Council feel that members of Council should each undertake some Committee work, the load being spread as far as possible, but at the same time preserving some "cross fertilisation" by a member serving on more than one Committee so that each is aware of the activities of others.

There are also a number of important technical and advisory Committees of Council, each of which is active in a particular field; in many cases these Committees are, in fact, the authors of much original action in the data processing field and the Society is indebted to those who give their time and knowledge to bear on many current and future problems.

The two main specialist group Committees, the business group and the scientific and engineering group, have a special part to play in an advisory capacity to Council, the two Chairmen acting as specialist consultants on matters of future policy to the Executive Committee.

The Committees appointed by Council are as follows (members of Council or the Executive Committee are shown in italics).

Meetings: D. H. Rees (Chairman), C. Berners Lee, *T. B. Boss*, L. T. G. Clarke, *L. R. Crawley*, G. Cushing, *G. M. Davis*, A. H. Dawkes, *P. M. Hunt*, N. Jonas, L. Lightstone, A. E. Newman, D. Triggs.

Publications: M. Bridger (Chairman), D. V. Blake, *P. G. Barnes*, *L. R. Crawley*, *G. M. Davis*, *H. W. Gearing*, S. Gill, *J. A. Goldsmith*, *J. G. Grover*, *J. G. W. Lewarne*, E. Mutch.

Business Group: P. V. Ellis (Chairman), *L. R. Crawley*, *R. G. Dowse*, J. P. Hough, R. E. Stevens, A. S. Waller.

Scientific and Engineering Group: R. A. Buckingham (Chairman), *P. G. Barnes*, R. Bird, F. S. Ellis, *A. King*, G. N. Lance, V. E. Price, J. S. Rollett, M. A. Wright.

Education: R. A. Buckingham (Chairman), *M. Bridger*, L. T. G. Clarke, *E. C. Clear Hill*, M. Geary, *G. H. Hinds, T. H. O'Beirne, E. S. Page, J. W. Wright, A. King.*

Standardisation of Scientific Programming Notation: C. Strachey (Chairman), S. Gill (Secretary), R. A. Brooker, A. E. Glennie, D. P. Jenkins, D. J. Wheeler, M. Woodger, *F. Yates.*

Data Transmission: R. G. Dowse (Chairman), *P. G. Barnes, L. R. Crawley*, M. E. Drummond, P. A. Long, *R. H. Tizard*, D. R. Turner, A. S. Waller.

Standard Glossary: G. C. Tootill (Chairman), G. B. Cook, *G. M. Davis*, A. S. Douglas, I. H. Gould, *A. King*, F. J. M. Laver, Mrs. J. M. Vincent, A. R. Wilde.

A further specialist Committee in the field of document handling and character recognition is being formed under the Chairmanship of J. G. W. Lewarne.

Another matter engaging the attention of Council is the representation of the Society on other bodies, particularly in the international field, formulating and commenting on proposed standards. Active work is going on both in this country and overseas on formulating standards for coding in relation to tape and cards, programming notation, data transmission and glossaries of computing terms. It is important that the Society speaks with one voice and that its representatives are fully briefed by the relative specialists. Some form of co-ordinating committee on standards is likely to be set up.

ASSOCIATE EDITORS

Readers may find it helpful to know the names and addresses of the *Bulletin* Honorary Associate Editors.

Analogue Computers:	To be announced later.
Book Reviews:	S. Gill, Ferranti Ltd., 68/71 Newman Street, London, W.1.
Conferences:	D. G. Barnes, 14 Sandpit Lane, St. Albans, Herts; and Miss D. P. Kilner, British Transport Commission, 222 Marylebone Road, London, N.W.1.
Design and Circuitry Development:	R. E. Sheppard, N.R.D.C, 1 Tilney Street, London, W.1.
Educational Establishments:	R. A. Buckingham, University of London Computer Unit, 44 Gordon Square, London, W.C.1.
Index:	W. J. Seally, Finance Department, N.C.B., Hobart House, Grosvenor Place, London, S.W.1.
Library Accessions:	F. C. Adey, The Librarian, College of Technology and Commerce, Leicester.
News from Manufacturers:	H. W. Gearing; and L. G. Reynolds, The Metal Box Co. Ltd., 37 Baker Street, London, W.1.
News from Overseas:	M. V. Wilkes, University Mathematical Laboratory, Corn Exchange Street, Cambridge.
Programming Developments—Commercial:	E. L. Willey, Prudential Assurance Co. Ltd., Holborn Bars, London, E.C.1.
Programming Developments—Scientific:	To be announced later.
Regional News:	To be announced later.
Reports on London Meetings:	G. M. Davis, 17A Oaklands Road, Bromley, Kent.
"Snippets" of Information:	G. C. Tootill, R.A.E., Farnborough, Hants.
Society and Council News:	D. W. Hooper, Catsacre, North Street, Rotherfield, Crowborough, Sussex.
Users—Central and Local Government:	To be announced later.
Users—Industrial and Commercial:	J. A. Goldsmith, Robson Morrow, 59 New Cavendish Street, London, W.1.

The other members of the team are:—

Honorary Advertising Editor:	D. V. Blake, 3 Hawkewood Road, Sunbury-on-Thames, Middlesex.
General Editor:	M. Bridger, 30 Roundhill Road, Leicester.

Contributions to the *Bulletin* should normally be sent to the appropriate Associate Editor. Where no Associate Editor covers the particular contribution, it should be sent to the offices of the Society or to the General Editor.

The latest dates for copy this year are: 5/1, 15 April. 5/2, 15 July. 5/3, 16 October.

COMPUTER COMMENT

Consolidation of BCAC into One Group

At a Luncheon on 7 December 1960, to mark the recent reconstitution of The British Conference on Automation and Computation, Sir Walter Puckey (Chairman) addressed the Secretaries and other representatives of the thirty-two organisations represented in the Conference. Sir Walter recalled that formerly the BCAC operated as a federation of three separate groups concerned respectively with the engineering applications of automation, automatic control and computation, and sociological and economic aspects. He stressed that the recent merging of these groups into a single BCAC Council in no way represented any contraction of interest; all three aspects continued to carry equal weight, and had balanced representation on the Executive Committee of the BCAC. He had therefore invited the senior officials of the BCAC member organisations to the luncheon to make their acquaintance and to meet members of the Executive Committee, to enable him to outline and discuss with them the activities and developments which the Executive Committee had in mind, to seek their interest and support, and to profit from their suggestions and experience.

Sir Walter recalled that the objects of the BCAC were as follows:

(*a*) To stimulate interest in, to spread knowledge of and to foster the development and applications of automatic control and computation.

(*b*) To afford a common meeting-ground for the adhering organisations whereby such of their activities as fall within the purview of the Conference can, if they so desire, be co-ordinated and extended.

(*c*) To encourage and, if desired, to co-ordinate the presentation at International Conferences of British papers whose subjects fall within the purview of the Conference.

(*d*) To maintain, as may be desirable, liaison with other countries which support such international conferences.

To carry these objects into effect, the constant goodwill and interest of the member organisations would be required, and Sir Walter was confident that the chief executives of all these organisations would do their part in fostering the growth of automation and computation in this country—a development so important to the life and progress of the nation. The BCAC had decided to set up three Panels to activate the following aspects of its work:

Education and Training—Chairman, Professor G. D. S. MacLellan, M.A., Ph.D., A.M.I.Mech.E. (*University of Glasgow*).

Research and Development—Chairman, Mr. J. F. Coales, O.B.E., M.A., M.I.E.E. (*University of Cambridge*).

Public Relations—Chairman, Mr. W. C. F. Hessenberg, M.A. (Deputy-Director, *British Iron and Steel Research Association*).

Arrangements were well advanced for the holding of a BCAC Conference at Harrogate from 27–30 June 1961, with the general title, "Automation—Men and Money." Its organisation was the responsibility of eight of the BCAC's member organisations particularly interested in the social and economic aspects of automation.

Plans were also in hand for the delivery, in the autumn of 1961, of the first BCAC Annual Lecture, which would be in the form of an authoritative review, by an expert in the field, of the present position and probable future development of automation procedures in British industry and commerce.

After a brief discussion these proposals were warmly received and fully endorsed by all present.

The British Computer Society is a member of the BCAC and its honorary secretary, Mr. E. C. Clear Hill, represents the Society on the BCAC Executive Committee.

University Symposium

A one-day symposium on "Computers for the Chemical Engineer" is to be held at Birmingham University on 28 March 1961. It is being organised by the Birmingham University Chemical Engineering Society, Graduate Section, and the Graduates and Students Section of the Institution of Chemical Engineers, Midlands Centre.

The papers to be presented are intended to show how computers can be of benefit to Chemical Engineers, and are of a descriptive nature. The morning session covers the principles of computers and their application to plant management and research. The afternoon papers show the use of computers in process control.

Further information may be obtained from "The Registration Secretary," Department of Chemical Engineering, The University, Edgbaston, Birmingham 15.

"*Mass-Radiography*" *Methods of Recruiting*

Engineers and scientists who visited the Eastern Joint Computer Conference, 13–15 December 1960, in New York, had an unusual opportunity to explore the career opportunities in the computer field. A Career Centre, sponsored co-operatively by the employers, offered access to company literature and career registration under an anonymous system.

The Centre was in operation in the New York Trade Show Building from 10 a.m. until 9 p.m. daily during the three-day conference.

A Career Centre works this way: An engineer arriving at the reception room fills out a registration form which includes his education, experience and interests. The information, but not the registrant's name, is tabulated electronically and immediately supplied to all companies represented at the Centre. Companies which have a vacancy or career opportunity for the man send an interview invitation to the reception room. The scientist, who by now has access to company literature, then chooses to talk with only those companies in which he is interested, and can reject the invitation from any in which he is not interested.

William A. Douglass, the creator of the Career Centre

concept, pointed out to our correspondent that recruiting at conferences "is now one of the facts of life."

Today's typical job-changing procedure in the US is for an engineer or scientist attending a national or regional technical meeting to visit the "hospitality suites," Douglass explained. "These prevalent hectic recruiting methods are ineffective both from the job seeker's position and from the company's point of view as well. There is a limit to the number of suites an engineer can visit in the course of a few days, the job description is often deceptive, and the result frequently is that the engineer finds himself in a job to which he is even less suited.

"For the company, it is an expensive method of finding engineers; it presents interview limitations, and often only succeeds in finding employees who become dissatisfied and are lured away by another company at the next meeting."

With centralisation, anonymity and the aid of an electronic computer, it is claimed that the Career Centre solves *all* the problems in one stroke and puts recruitment on to a dignified and business-like basis.

Two more Career Centres were planned, one for the February meetings of the American Institute of Electrical Engineers and the Annual Meeting of the American Institute of Physics, and one in March during the National Meeting of the Institute of Radio Engineers.

[It is feared that if similar techniques were adopted in the United Kingdom, managements might limit the leave of absence granted to attend such conferences!—Ed.]

Information Retrieval

Machine Indexing was the central theme of the Third Institute on Information Storage and Retrieval held 13–16 February 1961, at The American University in Washington, DC. Leaders in the theory and research of automation for indexing scientific documents and other information led the sessions on problems and progress in the field at the four-day program presented by the Center for Technology and Administration of The American University School of Government and Public Administration, whose address is 1901 F Street N.W., Washington 6, DC.

Weather Maps Drawn Electronically by Weather-Plotter

On 1 December 1960, the US Weather Bureau put into operational use an electronic computer-plotter that draws a complete weather map of the Northern Hemisphere in less than three minutes. The electronic unit reads weather information supplied in numerical form on magnetic tape and presents the information to a digital-to-analogue converter. The converter instructs the "mechanical hand" of the plotter to draw automatically the isobars, which represent lines of equal barometric pressure, on a 30 × 30 in. map of the Northern Hemisphere.

The Weather Plotter, developed and produced by *Electronic Associates*, was demonstrated at the Bureau's National Meteorological Center, which has two such units, one of which will be used on a stand-by basis.

According to Dr. George P. Cressman, director of the Center, the EA plotter produces a complete weather map in less than three minutes, compared with approximately 20 minutes required by the former hand-drawn method. He also noted that this automatic, electronically controlled method produces maps that are far more accurate than those hand-drawn. Information fed into the Weather Plotter is gathered from more than 500 weather-observation stations throughout the Northern Hemisphere. Observations are taken twice daily, at noon and midnight London time, and fed into the Center by teletype.

Forecasts, ranging from 12, 24, 48 and 72 hours ahead, are programmed on a computer and recorded on magnetic tape. The tape is then put on the Weather Plotter for reading, conversion and map plotting.

During the course of a 24-hour day, 64 weather maps are produced for various altitudes from sea level to 40,000 ft. Each map forecasts air-flow patterns for a particular forecast period. Maps of these air-flow patterns at 40,000 ft. and higher are prepared for use by the military and airlines in determining the best flying routes and altitudes for jet aircraft.

Immediately after each map is produced, it is distributed by facsimile telegraph to 26 US Weather Bureau stations throughout the United States for use in local and regional weather forecasting. Maps also are distributed by the same method to more than 600 military airfields and stations, airlines, universities and commercial weather forecasting operations.

Dr. Cressman said the reduction in time from 20 to less than three minutes for producing a map permits tightened deadlines with a consequent impact on the usefulness of the product. He also noted that, "The EA equipment is an important step forward in the Weather Bureau's efforts to automate weather data processing, weather analysis and weather forecasting. It is another link in the fundamental technological changes now occurring in the science of meteorology."

Mr. Lloyd F. Christianson, president of *Electronic Associates*, said that the Weather Plotter is a development of the company's line of data plotting equipment, which is being introduced for industrial applications such as automatic drafting, highway planning, map construction and data reduction.

He noted that units similar to the Bureau's Weather Plotter will soon be installed at Point Mugu and Monterey, California, and at Strategic Air Command Headquarters at Offutt Air Force Base, Omaha, Nebraska.

Metal Box order an Orion Computer

The Metal Box Company Limited have placed an order with *Ferranti Ltd.* for an ORION data processing system for installation at their central accounts offices in Worcester. Associated with the purchase of the computer will be ICT (80-column) equipment.

Existing staff will be trained in the operation of the new equipment and new routines. It is expected that the reduction in staff brought about by the introduction of the new equipment will be absorbed by the normal processes of staff turnover and business expansion.

SURVEY OF MODERN PROGRAMMING TECHNIQUES

by R. W. Bemer

This paper formed the basis of a talk given to the Society following the Annual General Meeting on 29 September 1960.

Introduction

In the business section of the *New York Times* there often appears an advertisement (not of my own company) for "Research Programmers to work in Macro-Assembly language development, Heuristic Programming and Artificial Intelligence studies, Symbol Manipulation and other advanced computer areas." You may have seen it. Even the lowly Machine Programmers are requested to "write programs for a variety of large-scale digital computers in the areas of Scientific Information Processing, Natural Language Processing and Information Retrieval Systems." At first this may sound like somebody has been reading Mr. Potter's books and this is merely one-upmanship in the programming area, but I assure you this is not so. Programming has indeed moved to glamorous heights.

Until about four years ago, programming was a more homogenised profession. This was to be expected in a relatively new field. However, so were the developments outlined in this advertisement. At present we have a large number of programmers in the world, certainly over 30,000, and the techniques used range from the ones described down to the most archaic. It is extremely unfortunate that the archaic end is the large end of the iceberg—the part under water. This is occasioned by the sheer rise in production programming, particularly in (but not restricted to) business and scientific applications. The production of generalised systems such as the FORTRANS, Flowmatics, various assembly programs, and rather complete systems like SOS for the 709 is a very big business. I hope that the end-purpose of this talk (and others like it, with published articles on the topic) will be to raise this vast body of programmers from the doldrums of outmoded techniques. I realised in 1950, after my first year with electronic computers, that the leverage factor between a good and bad programmer, or a good and bad technique, can easily be as high as ten or twenty-to-one. In a tricycle factory one is likely to become vice-president for increasing the output 10% at the same manufacturing cost. In programming, a 10% betterment of efficiency—that is in construction, not running efficiency—is likely to go unnoticed.

I shall try, in this talk, to give a summary of new and improved techniques in the programming field. Surveys should gather information in one place to enable proper perspective for review and weighting of importance. This survey will be restricted to generalised techniques and tools. Applications will not be covered, otherwise you might not get home until breakfast tomorrow morning. Despite much necessary overlapping, I am going to divide this talk into six parts as follows:

1. The elements of languages
2. Machine-dependent languages
3. Machine-independent languages
4. Analysis languages
5. Processor techniques
6. Operating systems.

Elements of Languages

When we instruct the computer to do work it is analogous to instructing another human being. In both cases we use languages. In early attempts the languages were at a very crude level and very awkward to use. Much of the recent pressure has been to use English as the language medium and instruct the machine almost indistinguishably from the instruction of another human. I have severe doubts as to whether we can or should go in this direction alone. One thing is very sure—the economic need to more efficiently communicate with machines has provided great pressure to re-examine the meaning and structure of language. Millions of us use the English language quite correctly, or at least as correctly as most, by having learned it through example and unconscious statistical selection. It may be possible that some day we will also teach machines in this way, but with present machine construction this is likely to be very expensive. Most of our present approach is devoted to teaching languages by a rigorous exposition of their form and structure.

There are many types of languages, and I don't mean Russian, French, or Pakistanian. There are the linear languages such as we have in writing or speech. There are the two-dimensional languages of tables and lists. There are symbol languages, such as flowcharts, and these by implication may be in many dimensions. There are pictorial languages. All of these have been used to communicate with computers.

The formation of language symbols is most interesting. Most all symbols have recursive, or combining properties. For example, the Chinese symbol for "riot" is formed of two identical symbols for "woman," with a broken line across to indicate a roof. Thus, to any knowledgeable man, two women under one roof indicates a riot.

Alphabets, however, are far more efficient, and have beautifully recursive properties. Except for a few vowels, none of the single characters are meaningful words in English, disregarding their use as single-character symbols for mathematics and the like. Theoretically—and I say theoretically only because George Bernard Shaw would otherwise arise from his grave—the characters in groups of one, two and three, etc., all have corresponding verbal sounds. These verbal sounds are then the analogue representations of symbols. However, I am afraid it would be very difficult to speak English to an analogue computer. The cost of storing symbol patterns for discrimination would be horrendous.

The digital computer is more fortunate because it can use binary bit representations for the elements of language. In common usage, bit representations are assigned to the letters of the alphabet, decimal digits and other useful characters. Using information theory, Shannon and others (myself among them) have used bit representations for entire words or phrases. However, to add new words or names the facility must always exist to represent the single characters by unique bit combinations. An analogy may be found in the representation of numbers by both coded decimal and binary notation. The binary notation corresponds to the word, since the entire symbol (that is, quantity) is represented by a single number, even though that has recursive forming elements of 0 and 1. The decimal number, or of any other base for that matter, is formed recursively by adjoining number symbols instead of letters. Let us not overlook the combinations of both numbers, letters, and special symbols, useful for part numbers and automobile licence numbers.

If I may speak categorically, the input to and the output from a computer is primarily a bit stream. Whether or not this bit stream is broken up into bytes, of which some bits are delayed in time so that a group or byte of bits enters the computer in parallel, is of no consequence. The size of such bytes, whether they be defined as a single bit byte, the 5-bit Teletype or Baudot code, the 6-bit byte of many alphabetic computers, or the 8-bit byte of certain new computers and numerically controlled machine tools is of consequence only to the convenience of the designer and the efficiency of his product. I recommend for your study the paper by Howard Smith, Jr., of my group, which appeared in the August 1960 issue of the COMMUNICATIONS of the *ACM*, entitled "A Short Study of Notation Efficiency."

Some of you may know that I have been crusading for some time in the interest of larger character sets. This has met with some success and you may note the IBM 7030—the production version of the STRETCH computer—accommodates a 256 character set, 8 bits per character. The attached printer will print 120 characters, including the upper and lower case alphabets, and all the other characters of the reference language of ALGOL. The input/output typewriter for the Bendix G20 also handles 8-bit ALGOL characters. This is of great interest to the programmer because he may now identify the unequivocal meaning of each character in a string without resorting to long programs that make many decisions on contextual relationships.

To say there has been variety in the methods of assigning bit combinations to characters is putting it very mildly. We have catalogued over 50 different selections. This Babel has probably been the prime factor in instigating an international standardisation effort in data processing. The British Standards Institution has been active here for years. In the United States, consideration of these problems has been left until recently to the various professional and trade organisations. However, the X3 Sectional Committee for data processing has been formed in the American Standards Association to straighten out this matter and many others at both the national and international level. Quite naturally, there is excellent co-operation between the British Standards Institution and the American Standards Association in these matters.

In actual practice, the bit representations do not need to be identical for interchange of information. The basic need is for a uniform collating or ordering sequence of characters. There is nothing more vital to the interchange of data and programs between computing machines than an identical collating sequence. There are certain natural collating sequences (Z is higher than A, 9 is higher than 0). I know of no reason why alphabet should be higher than numbers or numbers higher than alphabet other than historical precedent. Most of the millions of files produced by data processing machines in the United States are ordered with the numbers higher than the alphabet. Blank is a character in its own right and must be low. Collating sequence is an important factor in machine cost. Unless the ascending binary sequence of characters in machine representation is the same as the collating sequence, additional and expensive hardware will be needed to compare the keys of items to be marshalled or ordered.

Another basic element in interchangeability is data format. In order to be operated upon, data must be precisely defined. This definition may be by means of the instruction sequence itself, by other stored data, as in the control word technique, or by self-definition. For the latter purpose, I prefer a numeric subset of the 4-bit characters that contain the decimal digit 0 through 9, decimal point, minus, plus, comma, blank, and perhaps a monetary sign, dollars or pounds. In most present arithmetic operations the position of the decimal or binary point is accommodated by either floating point arithmetic or by aligning the implicit decimal point within the instruction sequence. This alignment could possibly be done automatically with a coincidence-

matrix detector if the decimal point is an explicit and separate character contained in the data. Some scaling might still be necessary, of course. Another type of instruction/data interaction is that where the data itself signals that it is of a special class which may or may not alter the instruction sequence. An example of this would be the terminator bits in the 7030, which indicate the beginning and ending elements of a vector stored in memory.

Although another element of language structure is the syntax, I will take that up under some other groupings.

Machine-Dependent Languages

As long as we have computing machinery there will be a machine language for a particular computer to understand. I will not guarantee that the form will stay that way it is today, because already

1. There are fixed word length and variable word length machines.
2. There are machines that operate on words, machines that operate on characters, and machines that operate on bit streams.
3. There are machines of one command and of more than one command in a single instruction, with one, two, three, four, and perhaps more addresses in a single instruction.
4. There are machines with 20 instructions in the machine language repertoire and machines with over 500 different types of commands available.
5. There are micro-instruction languages with which the programmer can get at each primitive required in fetching the necessary data to perform the operation; there are machines which have macro-instructions built into the hardware when a high frequency of usage indicates enough gain by paralleling the elements of execution. Examples of the latter are floating point, operations involving index registers, operations of indirect addressing and special table instructions such as the convert instruction in the IBM 709.

We may yet see machine languages identical to ALGOL or some other presently machine-independent language.

Expert programmers are well aware of the uncertainty in machine languages of the future. One certainty is that at the present time the engineers are far outstripping the ability of the programmer to use the machine, and there is a saturation point beyond which no amount of programmers can possibly speed up the writing of a program. Certainly more than two or three hundred programmers working together constitute a point of diminishing returns. We have no recourse as programmers but to go to the machine designer and say "help." I am pleased to note that the Atlas machine has taken many steps forward in this direction. The convenience of numerical symbolic addressing is one of the most important features that will reduce translation time and programming effort.

Given a particular machine-dependent language, there are many interesting tricks and techniques which a programmer may use, sub-programs for counting the number of 1's in a binary number, for instance, or tricky mathematical sub-routines. Although not exactly applications, such techniques are nevertheless also excluded from this treatment. Let us leave machine-dependent languages with only the reservation that eventually we have to convert the information we give the machine into this form.

Machine-Independent Languages

Machine-independent languages may be divided into two groups—and I do not mean scientific versus commercial languages. This is an entirely different partitioning. Machine-independent languages are either *procedure-oriented* or *problem-oriented.*

There is a great deal of confusion existing between these two terms. It is unnecessary confusion because the distinction is simple. The procedure-oriented languages are available for one to describe *how* the process is to be carried out. With the problem-oriented language one needs only state the problem. Heuristic programming is of course only the upper stratosphere of problem-oriented languages. There are many of these in existence today, of a simpler nature. As an example, take what is miscalled (in the United States) a sort-generator. What they really mean is ordering, or, to use the British term, marshalling. The input to such a generator would be items such as internal memory size, number of tape units, suspected bias in the ordering, record size and layout for the items to be ordered, preference for ordering method, grouping or blocking information, and many other items of information or advice. Inherent in the sorting generator is the pseudo-intelligence about the problem which will, from the intersection of this information and certain basic skeletal routines, construct an efficient operating program. The programmer may have called for a distribution or a sifting sort. He did not tell the machine how to accomplish a distribution or sifting sort. Had he actually written the program for a distribution sort he would probably have done so in procedure-oriented language.

Many of you have undoubtedly noted the metalinguistic formulae in which ALGOL 60 is described. This is due to John Backus, previously known as the developer of the FORTRAN program and language. I trust I may be excused for considering this a tremendously more important development than FORTRAN. Algebraic languages did exist before FORTRAN—Rutishauser's and that of Laning and Zierler at *MIT.* I believe Brooker's work was also simultaneous with FORTRAN.

This meta-language seems to me a remarkably rigorous means of describing a linear or string language. One would assume that the process should be recursive. That is, there should be a meta-meta-language with which to describe the meta-language, and so on in depth. I have always been convinced that such rigorous formation rules tend to simplify the translation process, just as in working at the aircraft factories during the war I found that the lower degree of the profile curve, the

better the air liked it. I was particularly pleased to hear from Peter Ingerman, University of Pennsylvania, at an ALGOL discussion during this summer's ACM meeting, that they had some difficulty implementing non-recursive procedures in ALGOL. When they redefined the procedures to be recursive everything was much simpler. In other words, a sounder and more generalised structure forces the programmer to do things the right way.

You are by now all familiar with the trend in scientific machine-independent languages through FORTRAN, UNICODE, Math-matic, Auto Code and such to the present state with ALGOL 60. Although by no means complete (in fact, I consider it still quite experimental) ALGOL is a far superior language to any of its predecessors. I know of four related processors for ALGOL in Germany; in the United States, processors have been written at least for ALGOL-like languages for the Burroughs 220, the CDC 1604, and its prototype Countess. An ALGOL processor exists for the 709/7090, and ALGOL processors are being constructed for many other machines. I have enough faith in the eventual future of ALGOL to have caused a program to be constructed which converts from FORTRAN source language into a rather stupid ALGOL. I have been asked many times why we did not make it translate from ALGOL to FORTRAN so that the existing processors could be utilised. The answer has always been that we wish to obsolete FORTRAN and scrap it, not perpetuate it. Its purpose has been served.

A similar revolution is now taking place in the area of business languages. Under the sponsorship of the US Department of Defence there has been formed the Conference on Data Systems Languages (CODASYL). Although this conference has other long-range aims, its initial and most urgent purpose was to synthesise, from the existing business languages such as Flowmatic, Aimaco, and Commercial Translator, a somewhat universal language in the spirit of ALGOL.

This language, COBOL, is nearly complete in its definition. Its construction was beset with many more difficulties even than ALGOL. For one thing it had to handle almost all the features and classes of problems that ALGOL does in addition to many others. Let there be no mistake about it—business and commercial problems are vastly more difficult of solution than are scientific problems, at least in their translation to machine operation. The scientists and mathematicians, in constructing ALGOL, drew upon a workable language of mathematics that has been in existence for hundreds of years. Their new contribution was the reduction of the verbiage that the mathematician normally finds between the formulae to algorithmic form in a more concise notation. On the contrary, business practice has differed wildly.

The constructors of the COBOL language were beset by many new problems and I fear that in their initial attempt they ignored the rigour and syntactic beauty that a definition by meta-language would have gained them. There has been a general resistance on the part of *IBM* and myself to the willy-nilly adoption of COBOL in its original form. We knew what was wrong with it and tried to say so in the manner of elder statesmen. I am pleased to say that nearly all these basic flaws have now been removed. *IBM* is committed to produce COBOL processors for many of its computers on the assumption that the official form of the language will be revised no oftener than once a year. Practically all major producers of computing equipment in the United States are committed to COBOL processors for their machines.

One might now ask if ALGOL and COBOL are the end. I must say no, for part of the work the American Standards Association set up under its X3 Committee is a project for common programming languages. I suspect there will be those who walk into the X3–4 Sub-Committee and expect to find ALGOL adopted as a standard. I expect the same may be true for the COBOL proponents. Having played the scientific against the commercial and vice versa, Saul Gorn and I have reason to believe that this is the very lever needed to force a fusion into a single language for both scientific and commercial work.

If machine-independent languages are to be standard, they must be standardised according to a set of rules of graduated stringency. Adoption of a particular existing language as a standard would be fallacious. For one thing, a standard requirement should be that the language be expressible in the meta-language of Backus or some other development of this nature. For another, all languages should be clearly partitioned. The commercial languages are now in three parts, reminiscent of Gaul (!); namely, procedure, data description, and environment. ALGOL does not have separate data description because it operates only upon floating-point variables or fixed-point variables with rigid rounding and truncation principles not suitable to business. ALGOL does not have an environment section, and it could certainly use it.

I further suspect within a period of two years a fourth section will be broken out of the language, a section exclusively reserved for time-dependencies and relationships. At present we are writing too much procedure into our problem solutions. Combinatorially, there are many different ways of constructing a flowchart to do the same problem. The variations are limited only by the time-dependencies. That is, A must be computed before B, because A is an input to the computation of B. If, for example, both A and B are input to C, it may not matter to the programmer whether A or B is computed first, but depending upon certain frequency information and other knowledge the compiling routine can well make this decision.

We can look to see (within perhaps two years) an international machine-independent language of the procedure-oriented type which will be suitable for both scientific and commercial work and will be heavily partitioned into organisational entities for the reduction of programmer effort. The processors which accomplish

the translation of this language to machine language will be required to be extremely clever and intelligent.

The problem-oriented languages are an upcoming and useful class. In this group we have sort generators (as mentioned before), report generators, file maintenance and updating generators, and table generators. All of these are very highly specialised towards certain frequent and recurring classes of operation. The investiture of the necessary and requisite intelligence into the program is economically justified by the frequency of need.

Let us take the report generator for an example. Input to such a program would be a description of the physical layout of the file, its component structure and the detail structure of these components. The semi-pictorial layout of the output is also required, with indications given of the pagination, margin, number of lines, grouping, spacing, indentation, etc. For a typical report the headings are lettered in exactly as they are to be produced from a typing element in the proper column and row. The working information is laid out exactly as it is desired to be seen with proper decimalisation and auxiliary characters. (Some means of relating this output to the structure of the input file is also necessary.) The cyclical characteristics of data must be specified. It takes a good deal of programming effort to write a good report generator, but there is an extreme pay-off when you invite the vice-president down and hand him an input sheet and say, "Make up your own report." He is shown the simple rules, the information is key-punched and fed to the machine with the working file, and the report comes out in a matter of two or three minutes exactly as that vice-president specified it. It is remarkable how much support a computing installation can get that way.

To finish with machine-independent languages, I should like to emphasise the importance of jargons, and what they do for us. When one considers, for example, the jargons (or dialects) of ALGOL such as NELIAC, CLIP, JOVIAL, MAD, etc., it can be seen that the external appearance of the language is quite a bit a matter of taste. ALGOL reflects certain distinct choices in a matter of exterior form. It has been noted by Julian Green in his work with ALGOL processors that there appears to be a rather rigorous sub-language created from the scan of a string language. This appears to be common regardless of the jargon used. Remarkably enough, it appears to have the quality of Polish Notation with an alternating sequence of operator, operand, operator, operand, etc. This does seem at first to give support to those that prefer Polish notation as the human programming language, as in ADES II and the APT programming language. The group that it actually supports is that which would like to see a specialised jargon for each field of computational need. Mike Barnett, for instance, carries this one step further with his so-called "Macro-directives," which are highly specialised jargons for a particular field. These are translated into an intermediate language such as FORTRAN or ALGOL and then processed into machine language.

Brooker has been particularly keen on this, as evidenced by his paper on a self-defined phase-structure language. It would seem that the computer is versatile enough to take specifications of language structure and construct its own rules for translation to the sub-language. Of course, this is directly related to the problem of translation of natural human languages.

Analysis Languages

This is a subject I can touch on only briefly because the field is actually in its infancy, but basically the analysis language should provide the tools to describe the operation of a total system. These are the languages we may expect our systems and procedures analysts of the future to use in describing their problems. There are prerequisites to successful language of this type. Among them are more rigorous methods of describing data organisation and set membership. I imagine they will be much more pictorial, being two- and perhaps three-dimensional. Examples of tabular languages are already in existence, developed by Hunt Foods and by General Electric. In the simplest form the dividing lines between the columns and rows represent and/or conditions. The resulting procedure or operation is described in a column following a double rule. In reality much of this is simply making Boolean algebra more palatable to the user by transformation of the language to a form more compatible with his previous experience. The development committee of CODASYL is extremely concerned with this problem. They point out, and rightly so, that actual programming is often a rather small part the entire analysis problem of today.

Processor Techniques

Two years ago programming was rather in the doldrums. It seemed then that the twenty-five to forty-five man-years necessary to write a major processor were supportable only by manufacturers. Users and universities rebelled at this and so did the manufacturers because of the heavy programming costs. Now we find universities that can write with two man-years of effort better and more sophisticated processors than those which would have required twenty-five man-years as late as 1958. I ascribe this in large part to the development of symbol manipulation techniques.

At an ACM Council meeting a year ago, John Carr was rather perturbed by criticism of ALGOL since he had a large hand in the formation of the effort, and asked "Can anyone tell me just what is wrong with ALGOL?" It fell to me to answer the question and I said, "Simple. It's not a data processing language." In short, ALGOL could not be written in ALGOL. Assembly programs can be written in their own language; why not machine-independent languages? To answer that this is theoretically impossible is wrong. Symbol manipulation is the link. When you are going to ship a language with

its translator out to face the world so that it can do virtually any problem, you might as well consider one of the most general of these problems. This is the problem of translating from itself to a machine language. In fact, this is the acid test.

When ALGOL came into being as ALGOL 58, we were already embarked upon a language called XTRAN, designed to supplant FORTRAN. Indeed many of the characteristics of ALGOL were born in XTRAN. I asked Julian Green to run an effort to make an experimental processor for ALGOL. He was given only two rules:

1. Nobody that ever worked on a FORTRAN processor was to be associated with the project for fear of prejudice.
2. The processor was to be extremely flexible to accommodate expected changes in ALGOL.

The result of this is an experimental processor still carrying the name XTRAN but capable of providing as many different varieties of ALGOL as one needs. The reason for this is that XTRAN is written in its own language. Symbol manipulation elements have been added. Another successful project of this kind in the United States was undertaken at the System Development Corporation with the languages CLIP and JOVIAL.

As I said in my introduction, most production programmers are unaware of such techniques. The problem is how to convince them to utilise these new techniques. One possible answer lies in a course on compiler construction just given for the first time. This course lasts one week. The first two days are devoted to a special language for symbol manipulation. During the next three days each student writes a complete compiler in this symbol manipulation language and actually checks it out on a machine, in this case the 705. The compiler is a very simple one, and they do not write anything for recursive procedures. Yet it is complete, it works, and is written inside of one week.

Perhaps the second greatest contribution to the programming art in recent years is something we wanted very much to do one or two years ago and only recently discovered how. This is bootstrapping. (I hope the term has the connotation in the United Kingdom as it does in the United States.) In any event, it means to use every possible facility that you have constructed so far in the construction of any new facility. This is not limited to a single machine but may also be extended to moving processors from one machine to another. The most difficult part of bootstrapping is to get that small initial handhold. Normally this starts with handwriting of an origin feature, the assembly of a few instructions, a decoding table for operations and addresses, an assignment feature to actual addresses and a few other such functions. With these facilities one starts to program and moves slowly in an ever-widening circle.

This is the classical method. It was not good enough for Bob Shapiro of the XTRAN project. Shapiro came from the University of Chicago and was not bound by what any other programmer had ever done. He decided that the first tool he needed was a scan to break apart and analyse the elements of the input language. However, he felt that one of the things the scan ought to be able to do was scan itself. So Shapiro wrote what he thought the scan ought to be and then he played machine, imagining the scan scanning the scan. As he did so, he wrote down the machine instructions that he thought the machine should produce in so doing. He then entered these same machine instructions in the computer and actually fed the scan through the program. In fact, again scanning the scan. This process produced a program for scanning which at first, of course, was not quite the same as that Shapiro had written. He kept at it until the output program in the machine was identical to the program that actually had scanned it. With this he completed his first major bootstrap and saved an enormous amount of work.

Bootstrapping is, however, a more useful device in modest present-day systems. As an example, we were required to produce a processor for a new machine, the 7070. There was a choice between starting from scratch or doing a wasteful job of writing a single translator on another machine—in this case the 705. After some initial opposition I persuaded the production people to write a program in 705 Autocoder which performed the translation from 7070 Autocoder to 7070 machine language. After all, this is a production problem one might be expected to encounter with such a generalised program. The 7070 processor (that is, the processor which would actually run on the 7070) was then written in the full-blown language, taking advantage of every feature available. This was then processed (virtually once and once only) on the 705 to produce a processor which would actually work on the 7070.

The elapsed real time in thus producing the program was greatly reduced, which is very desirable in these days of automatic design and production of machines. We received a bonus we hadn't quite counted on, actually. Now we have one 705 running around the clock, doing nothing but assembling 7070 programs for customers that do not yet have their machines.

XTRAN as an experimental processor has changed form many times, but the basic transformation from independent language to machine language has remained the same. One starts with the scan which produces macro instructions, possibly of a three address nature and quite independent of data configuration. The next step converts these macros to other macro instructions which are data-dependent. For instance, in the original macros we may have been attempting to add a fixed point number to a floating point number or perhaps two fixed point numbers that required decimal alignment, which was not necessary to consider at that time. The next transformation was either to symbolic machine language or direct to machine language through generators. Anatole Holt uses a diagram for this process that I like very much. It is a simple parallelogram which is completely below the base line. This base line represents a dividing position between machine-

independent and machine-dependent characteristics. Holt's diagram shows that the transformation is a gradual one through many steps. At each stage there must be a mapping from one form to the other so that no information is lost.

I think this is a good time to dispel the UNCOL myth (Universal Computer Oriented Language.) According to its proponents, all machine-independent languages would translate into UNCOL and UNCOL would be translated to all different machine languages. Apart from the fact that UNCOL has been demonstrated, through the success of CLIP and XTRAN, to be unnecessary, there are certain technical reasons why it cannot exist—excluding if you will the Turing machine. Since UNCOL must comprise the set of all possible machine level operations, it is likely to get outmoded as soon as someone develops a new one. For example, I wonder whether the UNCOL would have included the look-ahead feature of STRETCH if they had designed it five years ago? Then, too, it would seem that to be acceptable to all machines UNCOL would have to translate into the lowest common denominator among all classes of machines and thus the efficiency on each and every object machine would be minimal. I am afraid that as it is presently proposed, UNCOL is a miss, or myth.

To my mind there is an intermediate language form which will serve this same purpose. The only real difference between machine-independent and machine-dependent languages is that they have different constructions reflecting the different organisation of the human mind and the computer mind. To go from one to the other there must be an orderly transmutation of information. I submit that tables and lists can easily be the common denominator for this purpose. Several powerful list processors have already been constructed—LISP of McCarthy and Mealy, and the Newell–Simon–Shaw processors. There are indications from the realm of information storage and retrieval that the day of the list processor has just begun. The ability of various trees to reference recursively both backward and forward on many program levels indicates that they are powerful enough to perform the stated function of UNCOL as an intermediate form. As an example, the XTRAN scan decomposes the string continuously into a matrix. The semicolon as a statement separator is never treated differently from any other character. As a result, arithmetic computations may be optimised over whole sections of the program with redundancies removed. Consider it this way—if one makes a list inside the processor of all the variables that ever have an addition operation performed upon them, it will be detectable that B + A is the same as A + B. All that is required is an ordered list and a search for duplicates.

The translation from a machine-independent to a machine-dependent language raises some interesting speculation. There are two courses open today. One involves translation from the machine-independent language to an intermediate assembly language in machine-like form, with the operators and operands given mnemonic English equivalents. A separate assembly operation then converts this form to machine language. The other alternative is direct generation of machine code. The latter is not enjoying much favour these days. I suspect it will in the future. The proponents of the double step process tell us that machine-independent languages cannot presently state every type of problem, whereas assembly languages can. Therefore, correct machine code in assembly form may be adjoined with the output of the first translation and all translated by the assembly program. This is a safe way to play it, and for today perhaps the most practical for production programming. It is predicated on the assembly and translation processes being long and tedious, such that one could not afford to start over from scratch each time an error is caught or a change made. Direct generation, on the other hand, is based on the principle of recompilation from the beginning each time, although perhaps certain tables of correspondence may be saved. By avoiding the intermediate assembly language step much duplication is avoided and the running program may physically replace the source program in memory.

Another important technique in today's processors is that of flow optimisation. It is well known that there are more devious ways of going to a point four blocks down the street than by walking to it directly. The average programmer left to his own devices is too likely to take many of these detours. The route is best left to the intelligent processor. Perhaps the most complicated section in the various FORTRAN processors is that for flow optimisation through the use of predecessor and successor logic. As you know, the programmer has the option of specifying expected frequency of taking various possible paths at branch points as override information. The processor takes as much of this information as the programmer gives it and constructs a rough test program. Test values of the variables are generated randomly and the test program is exercised with these values to determine any unknown branch frequencies. With this information the program is then reconstructed to optimise the flow such that the most used paths through the program take the shortest time. Of course, if this penalises greatly a slightly less used path, a different choice must be made. Similar to the transportation problem, this technique is in effect a prior optimisation of the program.

Many post-optimisations have been tried with success. This is particularly necessary when we go to macro-instructions to decompose a string language. Normally the macro-instruction generators do not talk to one another. It may well be that the generation of two successive macro-instructions will engender some extraneous commands—multiple store, for example. Other crude rules for optimisation and modification of a program after it has been created fully have been developed.

As one who was brought up on interpretive programs in the early years, it amuses me to see that the compiler is not the last word. To compile implies that you know

everything about the program beforehand and all the external characteristics and conditions. In today's multiple processing systems this is definitely not so. Many hardware assignments must be made on-line during actual running. Furthermore, an interpreter is often a more compact form of instruction, whereas a compiler might generate as many as a hundred different ways of doing something, all of which must be maintained in memory in case their particular call should occur. The interpreter effectively generates the proper coding upon demand. The former reason for the unpopularity of interpretive programs was the length of time required for the fetch and interpretation cycles. With proper hardware design, such as that of ATLAS, this is not necessarily a problem.

The interpreter also comes into its own when there is a difference in balance between computational equipment and printing and editing equipment. As a case in point, take a 7090 and a 1401. The 1401 is a small machine with big off-line editing and printing characteristics. To asynchronously operate such equipment on-line with a large machine in a multi-program fashion would require much control information and prior editing. In this case all the 1401 would do would be printing. We have determined that it is very effective for the large machine to construct an interpretive control language as its output, together with the resulting data. The 1401 is nicely able to interpret these control and editing instructions with no loss of printing speed.

A problem of recent interest is the naming facility in processors. I know the English have laughed at some of the three- to five-letter names one encounters in American programming systems. I admit this is quite unnecessary and I apologise. The possible names one could use of any number of characters form a very sparse set. It is very expensive to carry around character by character representations in the compiling and translating process. These names are meaningful only to the programmer. They may be exchanged for compact binary representations for use in machine processing. A double list of these relationships is maintained for availability whenever output is required.

The problem of locating files by their names is related to this. With random access memory it is cheaper and more convenient to transform the name into a unique address which locates the related file rather than perform a special table search for the name and find the associated address. Lists come into their own here, and chaining techniques have been developed. That is, one converts the numeric representation of the name into a more compact number. In the address given by this number one should find the original name to serve as verification. If not, a chaining address is also given for the next try. The need for this is occasioned because the conversion algorithms sometimes produce duplicates in a more dense set. However, the expenditure of search time is far, far less than that for binary search. On typical files where 20% of the total files get 80% of the activity, the average number of searches made in a fully packed file has been determined as 1·12. Operating in this fashion is also good practice for the days of associative memory.

It was a combination of this chaining technique, the work of Shannon, and zero-compression techniques that led to the development of "Digital Shorthand" as a communications code. With computers on each end of a communications line, rather than the simple terminal equipments of today, we can transmit three times the volume of formatted text in compressed form, decompressing it at the receiving end. Facsimile may be sent at a saving of 4 to 1. This method promises large savings over expensive communications linkages such as Atlantic cables and satellites. An experimental 7090 program indicates that, with full utilisation, the cost of both sending and receiving computers is about 0·006 pence per word. Contrast this with 1s. 6d. per word day rate, London to New York, or 9d. night rates. This scheme will handle the full English dictionary at an average of 10·7 bits per word.

I have briefly touched on some of the more salient features and techniques that make large gains in both the writing of processors and the running of the programs they produce. Now to move to my final topic, the one probably dearest to my heart, that of operating systems.

Operating Systems

There has been a steady trend away from the combined human-machine operation and toward fully automatic machine-controlled operation. There is no doubt but what the vast increases in machine speed have forced this, but it would have been a desirable development even if speeds had remained the same. The first large automatic operating system, developed at General Motors for the 704, doubled the working efficiency of that machine.

One of the most important components of an operating system is the IOCS, which stands for Input/Output Control System. The proper scheduling of Input/Output is a far more difficult matter than writing the procedure. With IOCS we see new verbs introduced such as GET, PUT, INTERLOCK, OPEN and CLOSE FILE. All of these are compound instructions generated for maximum efficiency in feeding data to the operating procedures for producing answers.

Obviously a complex system of this nature has many levels of operation. Control must exist through hierarchies of overrides and limits. All component functions must be organised as subroutines eventually called by the topmost level of control. Since the scheduling function is one of these components there must be access to all machine states by interrogation or trapping. If trapping is used it must be capable of being disabled and enabled by the control program.

The scheduling function may be primitive or very complex. A good deal of development is being done by Codd and Held in the United States. Until a radical change in machine design, however, I am inclined to favour the primitive approach for a sensible profit;

too many experimental scheduling programs now take up more time in making the decision than the machine time they gain.

Assignment of operating units must not be made in the program proper. This is left to the operating system, which makes real time assignment according to what it has available soonest. For a tape unit, for example, this is probably the first unit the previous running program has relinquished. The programmer must in general refer to physical units by abstract names. This may be carried to the point of random loading of tape units. At the beginning of each problem the control program reads the labels on each tape unit to find out what exists there. It may also interrogate memory to find out how much is available and adjust the program accordingly for more efficiency. Self-adjustment to machine configuration is not costly for such a powerful device.

We would expect the program in the original language to be stored somewhere for ready access. Self-repair of programs may be effected by returning to the more compact source form. This is connected to the self-repair of the machine itself. A diagnostic program contained in the operating system may be called upon to test for faulty machine elements. Upon discovery, a message would be typed out to the service man, but rather than halt operations, either the current program would be readjusted by partial recompilation to avoid the faulty area, or another program might be started which did not require it.

Experiments indicate the possibility of successful diagnosis on a time-shared basis. This enables the programmer to essentially talk to the machine in real time at his convenience. Of course, all diagnosis is done and results obtained in the machine-independent language the program was originally written in.

Once a self-operating system is postulated and begun, no matter how primitively, we are on the way to remote shared operation of very large machines. The graphs of problems per monetary unit always show remarkable decreases when the machine gets larger and faster. I have long envisioned computers larger than STRETCH acting as large service and message centres. Because they must be tied in with communications networks for this purpose, they are automatically available for message control and forwarding, text and facsimile compression to high efficiency and low cost, and a variety of related functions. Certainly the very organisation in this manner will more than amortise the cost of the computers.

This concept would indicate that vast files of read-only memory will be an important requirement for the future. Even program instructions may be largely fixed and unalterable. Old-time programmers remember a lot of instruction modification, but how much do you need now with index registers, indirect addressing to many levels and symbolic addressing? I would venture to say that less than 10% of our program instructions ever get modified now, and the percentage will become much less.

I thank you for this wonderful opportunity to address you, and if you think that I have been talking too much "futures," read a copy of this talk three years from now and see how old-fashioned the ideas are.

DOCUMENT HANDLING AND CHARACTER RECOGNITION

A committee is being set up to examine the subjects of Document Handling and Character Recognition.

Any member of The British Computer Society who may be willing to serve and has some relative knowledge of the problems involved, is invited to communicate, as soon as possible, with

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EUROPEAN TRADE

The Federal Trust for Education and Research is planning to hold a two-day course on the 18th and 19th May on "The Future of the Seven". This follows a similar course held last October on "The Progress of the Common Market and its Effects on the United Kingdom". Proceedings of the latter have just been published by the Trust, price 10s. 6d. The course dealt with agreements between firms within the Common Market and relations between the United Kingdom and members of the Common Market.

Particulars of the Proceedings and of the next proposed course can be obtained from The Secretary, Federal Trust for Education and Research, 10 Wyndham Place, London, W.1.

PROGRESS TOWARDS CONTROLLING POST OFFICE TELECOMMUNICATION STORES BY COMPUTER

by H. H. Simmons

Summary of a talk given to the British Computer Society in London on 24 *January* 1961.

It is only possible for me to tell a straightforward story of the stores problem confronting the Post Office; outline the journey from manual methods to the acquisition of an ICT 1201 computer in the hope of resolving it, and the views and forward thinking of those engaged in implementing the project after two years of computer operation.

The task of the Post Office Supplies Department is to provide the 350,000 people employed by the Post Office with the 68,000 items of stores necessary to develop and maintain the essential postal and telecommunications services of the country. One of our biggest problems—a problem common to most stores organisations—is to maintain adequate but not excessive stocks in proper balance. To accomplish this efficiently demands up-to-date knowledge of the state of stocks, nationally, and ability to make frequent reviews to permit corrective action when and where necessary. In other words, to avoid loss of revenue and loss of public goodwill, because non-availability of stores causes inferior service, and the unnecessary tying up of capital in excess stocks, there must be sound stores control. The achievement of this apparently simple objective is made complicated by its size and the number of factors involved. The stores vary widely in size, shape and material, are derived from a variety of sources, and the periods required for their procurement vary from a month to many months. Some items are subject to daily movements, or even many movements in a single day. Others move only once or twice a year, and still others only once in several years although their retention against emergencies is necessary. Besides being held in six main stores depots the great majority of items are held in and issued from many small stores locations spread through the United Kingdom. So that throughout the whole stores structure of the Post Office there are in total several thousand stock movements each day, all of which affect the state of the national stocks both in quantity and value; if these are not properly controlled, the money granted for the purchase of stores is not being spent to the best advantage and unbalanced stocks—too much of some things and not enough or none of others—must be avoided.

For six years now we have been trying to streamline and mechanise procedures to produce data and analyses to ensure that the funds voted for stores and the stores items themselves are used to the best advantage. It has not been an easy period, nor a simple job.

The work of the Post Office can be divided, very broadly, into two parts—postal and telecommunications. The major part of the money provided for stores is spent on telecommunications items, about 30,000 of them, and therefore it is towards the better control of telecommunications stores that modern data processing methods have been directed initially. There is a lot of money tied up in stocks. Charges on excess stocks mount up.

The Importance of Balanced Stocks: The First Step, Punched Cards

Loss of revenue because of non-availability of stores is easy to understand, due to inability to connect subscribers to the telephone and telex and so on; and excess labour charges due to loss of output through having to switch labour from job to job, because of stores shortages, can be very considerable.

We have recognised for many years that to achieve adequate, but not excessive, balanced stock holdings, speedy and integrated information giving a complete, accurate and up-to-date picture of the national stores position, and the means of handling the information and figures while they are still "hot," are essential. In January 1954 a very considerable step forward was taken by the introduction of Hollerith punched-card machinery. This showed us quite clearly that the storage of information in such a way that it can be processed speedily and without the clerical drudgery which inevitably contributes to delays, and therefore ineffective figures and data, would lead us a long way towards our objective.

It might be as well to say here that the introduction of punched-card techniques disturbed a pattern of procedures of some forty years' standing. Although we did not recognise it at the time, we had with us a fine example of office mechanisation lagging behind production mechanisation. The telecommunications system had grown, become more efficient and more complex. The methods for controlling and maintaining its flow of life-blood—the stores to provide and feed the system—had not improved with it to anything like the same degree. The control situation had been patched, shored up and had bits grafted on here and there over the years, but no thorough or basic review had been undertaken. At a time when our back-room midwives were about to deliver the electronic child, stores control was still largely a matter of pen and ink methods. Not to put too fine a point on it, the introduction of punched cards caused a monumental procedural upheaval, which few of us concerned with it would wish to live through again. We experienced the full impact of what is euphemistically described as "human resistance to change" from the good souls who disbelieve in machines on principle to the straightforward, stubborn lad who had been settled in a comfortable rut for some years, and defied anyone to try to get him to emerge. In fairness, however, we might have done rather more about "pre-education," or appreciation, in those early days—but we were green at the game. Yet, even so, one important benefit emerged. When the time came to consider moving on to a computer we were in no doubt at all about problems likely to be thrown up by further mechanisation, and we did not repeat *some* of the mistakes made first time.

With the introduction of punched-card machinery requisitions for stores received from engineers were, and still are, immediately translated into punched cards. The punched card and computer installation is not used solely for statistical and analytical purposes *after* the routine cycle of receipt and issue of stores. The day-to-day transactions, translated into punched cards, are used to produce the documentation necessary to control the day-to-day tasks of receipt, storage, issue and accounting. The information in the detail cards is then built up and summarised into a form suitable for feeding the computer, and computer processing. From the detail card flow, in the first place, the following documents:

1. Selection (or Issue) Slip
2. Packing Note
3. Priced Delivery Note (or Invoice)
4. Ledger Statement.

In addition, some simple analyses and provision figures were produced by conventional punched-card methods; but from consideration of full development to the stage where we could get from the punched-card system the necessary *more comprehensive* analyses and statistics in a form suitable and ready for executive judgment, it became clear that long and complicated procedures would need to be devised and more staff and more quite expensive machines would be needed. Moreover, it soon became apparent that at the end of the month, quarter, and financial year there would be a considerable upsurge of work in the punched-card unit; and as the various analyses and returns were all wanted "*immediately*," and we could only move from process to process, or step by step, someone would be kept waiting. So that while it could not be denied that considerable benefits were to be extracted from punched-card methods we should after all be a long way short of the ideal. The "operator interference" involved in the movement of large blocks of cards from one machine to another, and the necessity for the most careful daily planning and control of operations to ensure that the final output was not delayed by failure to complete the prior sorting, collating and calculating operations, tended to produce necessary data too slowly for our full needs. This led to thought on the possibility of integrating some of these processes and the elimination of "operator interference"; and it was not a very long step from there to serious thoughts about the employment of a general purpose digital computer. Indeed, we tend to regard the installation of the ICT 1201 as the next logical step in the development of punched-card methods, rather than a new and daring excursion into the computer field.

Preparation for Computer

How we went about planning for and installing the computer is a fairly long story, but I will give a brief factual history.

A Computer Appreciation Course in November 1956 convinced us of the important need to get computers into proper perspective, because at that time a great deal of nonsense was still being talked about electronic brains. To this end, two week-end courses were arranged, with the collaboration of the *British Tabulating Machine Company*, for the more senior officers of the Supplies Department—Depot Managers, Heads of Branches and so on—the first in April and the second in November 1957—and each course was attended by about thirty persons. The object of enabling these senior people to get computers in the right perspective, with a slight bias towards de-bunking computers, was so that they would go back and talk to those under their control and spread the gospel that these wonder machines could, after all, be handled by quite ordinary people. This was successful. By the time the computer was installed the staff of the Department had a fairly general idea that what had arrived was a new aid to our work and not some invention of the devil which was to master all our activities. Computer appreciation courses have been provided—and continue to be provided for various levels of management; but experience tends to show that a greater awareness by all levels of management of the potentialities of computer techniques, rather earlier, might have been an advantage.

By November 1957 we had selected six men to take a programmer's course. It is worth while mentioning that these programmers were selected because they were under 40 (most of them well under 40) and they had, so far as our knowledge of them went, logical minds, imagination, drive, diligence, a capacity for patient investigation, *and a sound knowledge of the field of work to be programmed for the computer*. I mention this to bring out that we did not subject them to psychiatric or aptitude tests, and that we did not seek potential programmers with honours degrees and that sort of thing. They were, if you like, bright young men of our executive staff who appeared to us, after careful consideration, to have the necessary aptitude for the work. They all did very well on their programming course and immediately got down to their very considerable task and made very satisfactory progress. In selecting men to be trained as programmers *who were well experienced in the field of work to be covered* we are sure we were absolutely right, and convinced that it is better to teach programming to a man soundly versed in the functions of the organisation than to try to teach a trained programmer the functions of the organisation. When it is remembered that the men from Supplies Department took their programming course in November 1957 and that two complex programs had been written and proved and were available for customers test of the computer by June 1958; that the computer was delivered on the 17 July, handed over by the engineers on the 5 August, and operational work—not experimental work but operational work—was coming off the computer by 1 September 1958, there seems to us to be little doubt about it.

Installation and take-over went very smoothly. Out-of-service periods have been few and lower than we had anticipated. Such as have occurred have been of short duration. Initially facilities were given to another Government Department to produce analyses and statistics, and this with our own work and program testing for new projects kept the computer working for the first few months for an average of 6 hours each working day. Annual Valuation, special stock reviews and the extraction of by-products therefrom at the end of the financial year 1958–59 employed the equipment up to 12 hours each working day on Post Office work only. Currently 10 hours each working day is normal for three weeks in each month, and 16 hours each day in the fourth week. More work is available, but cannot be put on to the computer yet, because the question of shift work has not been fully resolved with the Staff Associations concerned.

The initial objective was to produce more speedily comprehensive provision statements which would give to the provisioning officers concise and accurate information as to the position of items under review. This was achieved on schedule and made possible, much earlier, positive provision action. Accurate and comprehensive provisioning statements

were made available in about a third of the time it took under the manual system. You can, I am sure, appreciate the effect this initial step had on the control of a stock holding which has been as high as £48,000,000. The importance of the ability to review provision positions accurately and rapidly cannot be overstressed.

Program Development

The original programs have of course been refined and expanded since first written to take in some difficult exceptions and to provide valuable statistical and analytical by-products, particularly in connection with the annual valuation of stocks. Thirty-six programs have been written since the computer was installed, and take care of some domestic tasks which entailed a considerable amount of clerical drudgery and more delay than is acceptable. It is noteworthy that about half these programs have suggested themselves, as it were; or, to put it differently, are the direct outcome of the operational use of the computer. The chief credit for this must go to the programmers for their initiative, mother wit and knowledge of the characteristics of the computer they are using. All in all, and this is important, we are beginning to get information about stores holdings which we have always known to be necessary but which it has not been possible to obtain hitherto by the means at our disposal. In the time available this evening, it is not possible to give you more than one or two significant examples of this.

The initial stock-review program was designed to scrutinise items at phased intervals of three or six months, according to their value. This proved not good enough. While it was not a bad idea to watch closely items which consumed money, from the budgetary control aspect, it was found that the cheaper, and therefore less frequently reviewed bread and butter items were in trouble. From the operational standpoint, two lengths of cable worth £10,000 were not much use if £5 or £10 of paper sleeves to joint them were not available. This situation was revealed and proved by the facility the computer gave us to review items "out of phase," or before the due time if you like, something we could never have done in a timely and effective manner by manual methods.

Another disadvantage of the initial stock review was that a statement was printed out for every item whether it needed attention or not. The current program, by using agreed minima and maxima, allows the computer to review each of 25,000 items *every month* but to print out statements only for those items needing attention because stock has been reduced to action level or is building up above an economical ceiling. Over the past nine months this selective program has reduced the number of statements printed out to only 6% of the 25,000 items reviewed each month—the computer having reviewed and approved, as it were, the position of the remainder.

To take an example in a somewhat different field. We had reason to doubt our stocks are properly disposed in the six main depots in relation to the areas which have to be supplied. Again, by an exception program we have been able to build up a picture, as a by-product of ordinary day-by-day transactions over six months. We are far from satisfied that our stocks are yet disposed to the best advantage, and as some 400,000 tons of stores move in and out of those depots each year, there is clearly scope for reducing handling and transportation and improving speed of service.

The ability of the computer to scan and process large files of data rapidly and eliminate clerical drudgery is demonstrated by the way we are now able to handle the calculations of payments to be made for cable. The price of cable is based on the market rates for lead, copper and paper prevailing two days after the date of our order on the contractor. This involved the perpetual employment of some poor souls on thousands of complicated calculations. Because of contractual peculiarities, they had, from time to time, also to *re*-calculate all the prices for as long as two years back. This problem proved a slippery one for the programmers, but the computer now does the drudgery and can calculate nine months back-transactions in eight hours.

Experience Gained

It is perhaps time to try to sum up where we stand after two years' experience of operational computer working. Computer experience is difficult to quantify; but there is no doubt in my mind that it must be regarded as a part of the return on capital invested in a computer. A paper like this cannot detail the short-cuts and valuable by-products derived from main programs. We are quite certain, however, that *using* the ICT 1201 has helped greatly to get us where we are and enabled us to see a long way ahead much faster than prolonged studies and theorising. I do not for one moment decry or belittle the importance of thorough study and pre-planning; but it can perhaps go on too long. Until theories are put to the test it is rather like pulling a barrow without wheels. Sooner or later you must "suck it and see"; and it seems to me, so far as our experience goes, there is room for seriously considering the advantages of getting a worthwhile objective on to a smallish installation and making it earn its corn, and using some capacity to assist the wider studies and so speed the achievement of the master plan.

We have not yet, of course, achieved the ideal of providing the best possible service to our engineers from the lowest possible stocks; we are still not quite sure where that balance lies; but we have moved some way towards it. I am sorry I am not at liberty to quote in terms of £ s. d.; but our stock holding has been reduced from eight months to five months. At the same time the number of requisitions which cannot be met on demand is lower than it has been for four years.

The ability to review items so much more frequently is invaluable; our provision officers (or buyers) receive essential information much faster and are in a much better position to take corrective action before trouble builds up to serious proportions. That difficult period, in which so much can happen, which we call "forward commitment" has been shortened, with correspondingly improved opportunity to spend our money to better advantage.

On the way we have, of course, saved staff; but normal wastage has prevented redundancy and there has been no problem there. Staff savings help to off-set planning and machine costs, but the *big money* in an application of this kind is to be won, as I have indicated, by providing first-class service to the field from the lowest possible stock. But in addition to our modest success, the experience we have gained from the *actual use* of a computer has broadened and accelerated our forward thinking and shown us how much more we can do, how we should go about it, and the type of equipment we shall need to achieve our goal.

Future Plans

We have under consideration quite revolutionary changes in the basic principles of our provisioning, I have spoken of the apparent need to re-dispose our stock holdings in main depots. This has pointed to a need to reorganise and re-cost our methods of transportation and handling. Given a greater measure of central stock control, we believe we could reduce our stock holdings and improve service to a degree which would have been regarded as "crack-pot" a few years ago. Added up, these tasks could appear a crushing burden of uphill work; but, given the aid of a suitable computer, and some management courage, we regard it rather as a tough job which can be successfully achieved.

We have always known that the ICT 1201 could not cope with all we need to do; but working with it has shown us what additional facilities we need with some certainty. We have taken the opportunity of giving four of our programmers programming courses on much larger and more powerful computing equipments. So, with the widened appreciation they have gained of our ultimate objectives by using the 1201, and at the same time appreciating the limitations of the 1201, they have been able to give us very useful guidance as to the type of equipment we shall need to bring our task to a successful conclusion.

In conclusion, I hope I have not made this sound too much of a success story. During our computer education I do assure you we have learned some humility. We have imposed our will on a computer; and in the process it has taught us how much more we have to do before we can say, with truth, we understand and can fully exploit this remarkable—and still very new—aid to management. We have had our ups and downs for the usual reasons, with which I am sure you are all familiar. The equipment has given us very little bother indeed; but we have had our share of trouble from what someone delightfully described as "the inherent unsuitability of human beings as vital links in a mechanised chain."

Discussion

In reply to questions, the Speaker gave the following additional information:

1. *Item code.* This is a six-digit code. The vocabularly is broken up into sections (first two digits), the last four digits specifying the particular stores item.
2. *Statistics for provisioning offices.* Estimates of future demand are at present based on cumulative statistics from the beginning of each financial year, prepared as a by-product of the stores control system. Alternative statistics are under consideration for later computer application.
3. *Form of requisitions and data transmission.* Requisitions are paper documents, coded for destination and stores item, etc., sent into the Supplies Department in batches by post, and cards are punched for each line-item requisitioned. Telex is being used experimentally, using paper-tape-to-card conversion after transmission.
4. *Errors due to wrong coding.* These were relatively high at first, but are now around 0·5%: many of these are detected by the storekeepers before despatch, because of peculiarities, one being abnormal quantities for particular items. Normal-issue quantities vary from depot to depot with relative telephone density.
5. *Safety stocks.* Weekly review might enable lower levels of safety stocks to be kept, and daily review might be even better, but this service would require additional computer capacity and the economics of the operation are under consideration. Minimum and maximum stock levels, programmed into the computer, are at present calculated from experience of demand and data accumulated by provisioning officers, including delivery periods by suppliers.
6. *Physical inventory.* The computer balances are checked periodically on a continuous cycle. Physical minimum-stock signals in the bins are also used to indicate danger levels.
7. *Ledgers* are post-posted (at present).
8. *Stores* are located at six depots in various parts of the United Kingdom, and all are covered by the computer.
9. *Prices* for annual inventory valuation are supplied by the accounts branch, for the computer to extend.

In conclusion the Chairman, Mr. L. R. Crawley, thanked the Speaker for his explanation of the system and emphasised that this was to be regarded as a report on steady progress towards the control of stores by a computer.

EMI Converter for Skylark Rocket Data

Skylark high-altitude research rockets, launched from Woomera, Australia, broadcast signals back to earth concerning ultra-violet radiation and soft X-rays from the sun, stars and space; and the conditions of ionisation in the upper atmosphere—its temperature, concentration and character. These data, transmitted in analogue form, are recorded on magnetic tape.

The Physics Department of University College, London, has placed an order with *EMI Electronics Ltd., Telemetry Division*, for magnetic-tape data processing equipment which will accept analogue telemetry data recorded on magnetic tape, and convert them into digital code punched paper tape, suitable for use on the digital computers at London University.

The EMI equipment will process in ten hours a 3,000-ft. reel of magnetic tape, which would occupy three people working for three weeks to process manually. Although the equipment is primarily intended for processing *Skylark* telemetry data, it has been designed with a high degree of flexibility, so that relatively small modifications would enable it to accept telemetry information from other sources.

RELIABILITY: COMPUTERS VERSUS HUMANS

by D. A. Bell

In certain on-line control tasks, such as chemical process control and air traffic control, the main impediment to the introduction of electronic computers is their relative liability to failure. The human operator is by comparison limited in operating speed—he can manipulate information at a rate of the order of 20 bits per second only—and is very inaccurate. For example, in punching cards* the typical error rate appears to be $1\frac{1}{2}\%$ to 2% and errors at the rate of one or two per ten thousand digits survive a second human scrutiny. By contrast, one would not expect to work with an initial error rate greater than 1 per 10^6 digits or an uncorrected error rate greater than 1 in 10^{10} or even 10^{12} in an electronic computer, and the amount of data-processing done by a human being in a second could be done in a millisecond in any reasonably fast computer. On the other hand, the unpredicted catastrophic failure of a human operator is rare—say of the order of once in 10^4 days—while a valve computer having an availability of better than 95% may yet suffer breakdowns at intervals no greater than one day. Present expectations are to improve this by a factor of five in large transistorised computers. (Does anyone claim better than this?)

The immediate question is whether the reliability of computers can be raised by several orders of magnitude by some system of redundancy. The biological analogy is discouraging, since in the human being the operative elements (neurons) are available in numbers of the order of 10^{10}. One would guess that even a large computer with 30,000 words of core storage would contain no more than 10^6 logical components; so that there is still a discrepancy of 10,000 : 1 which appears more than is needed on grounds of greater versatility. Fundamental work on the improvement of reliability of relay circuits by replication has been published by Moore and Shannon (1956) and Von Neumann (1956).

Typically, if an element of failure probability a is to be replaced by a "hammock network" (series parallel combination) of similar elements so as to reduce the failure probability to b, the number of elements in the hammock network must be at least $[\log b/\log a]^2$. This may be an upper estimate, since Kochen (1959) has shown that by taking account of the intended logical function of the unit in question, it is often possible to economise in the amount of replication required. Even so, the ratio of reduction achieved is less than one order of magnitude.

Consider now a medium-sized computer, say one with 4,000 words of core storage, which has some 20,000 critical elements such as transistors, diodes, load-carrying resistors, coil windings, and has an overall failure rate averaging once per 25 hours. If some elements are particularly liable to failure they should, of course, receive special attention until the computer reaches the state of never failing twice in the same place. It can then be supposed that a failure rate of 1 in 25 hours for the complete computer represents the result of a failure rate of 1 in 5×10^5 hours per component.

It has been proposed to use three computers on a "best out of three" basis; but this is not sufficiently secure for working 24 hours per day when there is a possibility of down-time of between $\frac{1}{4}$ and 2 hours for the daily fault. (A quarter of an hour in 24 represents only 1% lost time and the average may well be at least this on large computers.) Note that with three machines the weakness is not so much the daily occurrence of a fault as the time taken to rectify the fault. If one of three machines is out for one hour in 25, there is a 2 in 25 chance that one of the two remaining machines will also fail during that time, thus invalidating the whole installation, and this is much too big a risk. If the risk of a simultaneous failure of two computers at any time is to be reduced to 1 in 10^6, then the risk of failure of each during that time must be reduced to 1 in 10^3, and if the average fault duration is one hour, the time between faults must average 1,000 hours instead of the present 25 hours, an improvement of 40 times. However, the factor which enters into the Moore and Shannon formula for replication does not depend simply on the ratio of improvement required, but rather on the absolute level of failure rate: it is not $[\log (b/a)]^2$ but $[(\log b)/(\log a)]^2$. The following example shows the minimum replication ratios predicted by the Moore and Shannon formula for failure reductions of one-hundredfold and one-thousandfold from initial failure rates ranging from 10% to 10 per million.

a	$\left(\frac{\log b}{\log a}\right)^2$	
	$b = a/100$	$b = a/1000$
10^{-1}	9	16
10^{-2}	4	6·25
10^{-3}	2·78	4
10^{-4}	2·25	3·06
10^{-5}	1·96	2·56

On this basis it appears theoretically that a triplication of individual components would achieve greater reliability than the use of three complete machines, and there is a case for investigating the means of incorporating this amount of redundancy in the individual circuits.

It is, of course, desirable to include some further check, but with a high basic reliability it might be satisfactory to depend on the consistency of two rather than the best out of three. Some computers have used duplicate arithmetic units, while others repeat all calculations in a different form (e.g. using complements) and the choice between these two rests partly on a balance of costs between quantity of equipment and speed of operation.

* G. H. Hinds, "The Accuracy of Data Preparation," *Computer Bulletin*, June 1960, Vol. 4, No. 1, p. 7.

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A CRITICAL APPRAISAL OF COBOL

A report of the Working Committee of the British Computer Society Study Group No. 5 on Advanced Programming.

1. *Introduction*

The Working Committee was brought into existence as a result of a decision made at a meeting of the British Computer Society Group on Advanced Programming in March 1960. Members of the Committee come from nine organisations, five of which are computer manufacturers; their opinions as expressed below do not, of course, necessarily represent the views of the organisations to which they belong. The Committee has met regularly for one afternoon in each week.

The Committee accepted that COBOL appeared to be the most advanced attempt at a common language for business purposes which was available at the time, and was therefore worthy of detailed study. It greatly appreciates the free publication that has been made of the details of the language and feels that this has provided a timely aid and stimulus to the development of the subject generally.

The manual studied was the one issued in March 1960, and amendments which became available in the United Kingdom up to October 1960.

2. *Commonality Amongst Users*

A common method of expression is undoubtedly a desirable aim and in several circles is considered an economic necessity. It is well to remember, however, that a language is not an end in itself, but rather a means to an end. In the design of such a language it is important to ensure that the minimum of restriction is placed upon the user in the organisation of his system or in the full use of his data-processing equipment. Furthermore, the principal qualities of a user-oriented notation are those of simplicity of structure, a self-evident yet not unnatural method of expression, and the minimum opportunity for ambiguity either in what is grammatically correct or as a result of a single grammatical error.

Such demands are a great deal to make of any language, particularly of one developed only two years after the publication of the first language designed for commercial application. It would be an outstanding committee indeed that could produce such a language in the same time and subject to the same stresses as were the authors of COBOL.

To establish a mechanism for handling language extensions and modifications and thus to ensure the "Open-ended" nature of the language would seem contrary to the principal purpose of a common language. Nevertheless, it is realised that extensions and modifications will inevitably be found necessary from time to time, and this in itself presents a very real challenge to the establishment and maintenance of such a standard. The problems of language stability have already been found to have prejudicial effect upon the future of ALGOL as a common language for scientific purposes.

3. *Commonality Amongst Machines*

A "common language" is considered to be one which is appropriate for use with more than one type of data-processing mechanism. This in itself would represent a considerable step forward. The Committee feels strongly that the authors of COBOL have not made this step, nor any real attempt to tackle this problem. The degree of generality that has been achieved might be sufficient to cover all machines that use magnetic tape as the principal input/output medium and use a character base for internal representation. It is felt that in view of the wide range of their capabilities, some qualification of the claim to achieve "the maximum amount of compatibility on present-day machines" is necessary.

Since Input and Output represent a significant part of a data-processing system full consideration should be given to all aspects of the subject in source language terms. To those intimately connected with the computer industry the machine is regarded as a mechanism to which a range of peripheral equipment can be attached. However, the commercial user thinks of his problems chiefly in terms of input information and output results. Therefore, in the development of a commercial programming scheme it is necessary that there should be some shift of viewpoint, a shift which is not apparent in COBOL.

4. *Language Structure*

Character Set

The notation that is adopted for a computer orientated language is to some extent conditioned by the media used for program input. For example, the use of punched cards, with the limitations imposed on their codes by line printers, places a severe restriction upon the available character set; languages written for use with cards are usually dependent upon the use of fixed field positions.

In the design of a common language it might appear that neither the wide range of characters available with paper tape nor the fixed fields available with cards can be used. If the solution were to devise a language using only those characters available in all codes it would seem that only the digits 0–9, the letters A to Z and space were available, which would appear to be unduly restrictive. Additional syntax could be introduced with a tabular notation. At the other extreme, there seems little hope of achieving commonality with a character set satisfactory to all users. In choosing an extended set of 51 characters the authors of COBOL must have considered the effect that this might have on compatibility, although the committee can find no discussion on this point. For instance, the simultaneous use of the hyphen and the minus sign would seem to be particularly undesirable. It is possible to take the view that the range of characters should be that in normal business use, e.g. the standard typewriter set.

The extensive use of symbols with syntactic significance might significantly reduce the bulk of a source program. Indeed, it is difficult to see how a language like COBOL could

be devised without the use of symbols. It is felt that the syntactic significance of any one symbol should, where possible, be independent of context; however, if it is necessary for one symbol to have different functions in different contexts, the various meanings must not be easily confused, or be ambiguous. There is a body of opinion within the committee that would recommend a language with a maximum use of symbols. The statement in COBOL that "everything in the language would be correct English" has been particularly subject to criticism both as a principle and in its execution.

Divisions of COBOL

The classification of the information contained in a complete program into clearly defined divisions (i.e. Procedures, Data Description, and Environment) is one significant feature of COBOL. This work has not been completed, however, and it is the opinion of the group that, had this been completed, the limits of compatibility would have become more apparent. There are areas in which it can be achieved independent of the computing machinery involved. Other areas can be isolated in which compatibility of a more local nature is possible; all users of punched cards would be such an area, for example.

Although a proper classification of declarative and procedural information is necessary this does not imply that each should be presented to the computer for translation in distinct sections. Indeed, it is frequently desirable to include declarative information within the body of the procedure description. A particular example of this is the sentence label. The subdivision of a program into sub-procedures is frequently desirable and a small amount of declarative information is usually of local significance to an individual procedure. Data names with local significance can prove particularly useful.

Data Description

The committee also recommend a clearer subdivision of the data description section. The following four subdivisions are proposed:—

(1) LOGICAL STRUCTURE. This contains those abstract properties associated with each item of data, such as the name, the relationship with other items of data, and the range and scale of numeric items or the variation in length of alphanumeric items.

(2) INTERNAL REPRESENTATION. This contains the necessary details relating to the method of holding the data within the computer.

(3) FORMAT. This contains a detailed description of the way in which the data is held on any input or output medium.

(4) ENVIRONMENT. This contains the necessary details relating to the mechanism for handling the data.

With these subdivisions of the data description the limits of compatibility become apparent; for example, with a standard method of describing the way in which information is held on punched cards the FORMAT description allows compatibility between all installations that handle punched cards. By describing the FORMAT and sufficient of the INTERNAL REPRESENTATION the user implies input or output conversion and editing. The details of these processes are computer orientated and might well be handled by the compiler.

Within such a framework it should be possible to allow for a method of packing data, the details of which are handled by the compiler and not by the programmer.

5. *Procedural Statements*

The following comments are a few of those to be found in the minutes of the Committee.

Logic

A compound condition containing both the logical connectives AND and OR is made unambiguous in COBOL by the adoption of the convention that AND takes precedence over OR, whereas in fact both are distributive. It is suggested that the use of brackets should be made obligatory to remove any ambiguity, or, alternatively, that conditions contain either AND or OR, but not both.

General Arithmetic

COBOL limits this to the addition OR subtraction of a number of operands, or the multiplication OR division of two operands. There is no way of mixing the operations. Even the following simple statement is impossible:

ADD A AND B SUBTRACT C.

A running form of arithmetical statements would be more flexible, allowing, for example:

ADD A AND B SUBTRACT C GIVING D
MULTIPLY BY E DIVIDE BY F.

Rounding

Rounding may be required after an arithmetic operation or when information is moved from one area to another. It is also desirable to be able to round up as a single operation. It is recommended that rounding up, rounding to and truncating be introduced as procedure statements. In each case it is desirable to allow rounding to a given number, e.g. ROUND TO the nearest shilling.

Division with a Remainder

There is no provision for using the remainder from a division, although this is needed, e.g., if conversion is to be programmed. As a special register is provided for TALLY, it seems that a second register REMAINDER could also be allocated. Some machines do not derive a remainder automatically, and to avoid unnecessary routines when no remainder is required, some restriction might be placed on the calling for this remainder, for example within the same or next sentence.

Functions

Provision is very properly made in COBOL for the definition of new verbs as functions, with replaceable parameters. However, it is a serious drawback that a "noun" (i.e. the result of a process) cannot be defined and used as if it were a piece of data, but a verb must be executed to create it. Noun functions are allowed in other commercial languages and would be particularly useful in COMPUTE statements. Obvious examples are the "variance" of two quantities, and "square root" which occurs frequently in statistical work.

Ambiguities

It is considered undesirable to include in a program a statement that changes not merely the action but actually the value of another statement. This is a dangerous facility for a commercial language since it makes it impossible to determine, by inspection of any one procedure, either its action or the factors that affect it.

This source of ambiguity is shown in COBOL by ALTER.

Example:

The following sentence is syntactically correct in COBOL.

> "PERFORM CALCULATION UNTIL P EQUALS Q AND R EXCEEDS S AND READ STOCK RECORD; AT END ALTER XXX TO PROCEED TO YYY *AND GO TO ZZZ*."

The COBOL translation of this is as follows:

> "First perform repeatedly the procedure called CALCULATION until P equals Q and R exceeds S. Then prepare to read a STOCK RECORD. If no such record is available then alter the GO TO statement labelled XXX so that it now reads
>
> GO TO YYY,
>
> Then *go to* ZZZ.
>
> If, however, a stock record is available then read it *and go to the statement labelled* ZZZ."

This example also shows another dangerous ambiguity. The sentence as it stands would appear to have either of the following incorrect meanings:

(1) "At the end of the file alter XXX so that it reads

'PROCEED TO YYY AND GO TO ZZZ' "

(which has at least the merit of being nonsense); or

(2) "At the end of the file only, set the alteration and then go to ZZZ."

In fact, as shown above, the jump to ZZZ takes place after the reading of a stock record, as well as at the end of the file.

A similar situation can arise following an ordinary use of OTHERWISE.

6. Data Description

Further detailed comment on Data Description is not considered worth while, except that it would be desirable to allow for mixed radices, for example Sterling, if COBOL is to be used in the United Kingdom. This also applies to literals.

7. Background of COBOL

The Committee regrets that a "common language" should be produced under heavy pressures such as would appear to have influenced the authors of COBOL. The task is one of considerable responsibility requiring not a trivial preliminary study of the subject. It is also regretted that of the ten organisations participating on the Short Range Committee three are Government departments, six are computer manufacturers, one is a computing service group, and none represent the other varied interests of commerce. It is felt that consultation with other user groups would have been desirable.

The Committee recognises the financial necessity in certain circles for a common language, but views with concern the already apparent tendency of individual implementers to adapt and develop COBOL so that it should suit their individual requirements. The problem of maintaining the uniqueness of a common language is not the least of those facing the CODASYL Committee.

8. Conclusion

A suitable form of common language has not yet been arrived at. Full compatibility between machines has not been attained and it is not possible to judge without further evidence whether COBOL is suitable for common business usage. The language itself contains the elements of several useful concepts and has, therefore, contributed to the development of the subject. In spite of this a number of structural defects have been isolated and the group cannot recommend it for general use without some modification.

Before any further attempt at a common language is made a thorough and detailed study should be undertaken of users' practical requirements, and the setting up of suitable machinery to do this should be regarded as a matter of urgency.

Use of COBOL

The Committee discussed at length whether it would be worthwhile to accept COBOL as a temporary expedient so that commercial firms might gain experience from which to estimate their requirements. It came regretfully to the conclusion that experience could as well be gained from manufacturers' own languages, since in the process of implementing COBOL manufacturers were forced to adapt and amend it, thus destroying the only argument for such a temporary use.

Polaris Submarine Simulator

It was announced at the end of 1960 that a contract to produce a large-scale, three-console analogue computer system as a major unit of a simulator for the Polaris missile-launching submarine programme had been awarded to *Electronic Associates Ltd.*, of Burgess Hill, Sussex, by the Marine Division of Sperry Gyroscope Co. (US). It covers a PACE 231R analogue computer system with low-drift amplifiers and special time-scale networks for real-time simulation, and is similar to other larger PACE computer installations in the United Kingdom.

The unit will form a major part of a complete submarine simulator to be built and operated by Sperry's Marine Division for the US Navy in solving navigational problems of Polaris missile-launching submarines.

CORRESPONDENCE

Letters from readers are welcomed, and should be addressed to the Editor, The Computer Bulletin, Finsbury Court, Finsbury Pavement, London, E.C.2. The name and address of the writer must be given, but will not be published if requested.

Cobol

Sir,

All members of the Society will appreciate the detailed examination of COBOL made by the Working Committee of Study Group 5 on Advanced Programming. In some cases its members gave up time from studies of their own languages and compilers in order to contribute to the "Critical Appraisal." Nevertheless, there will be many, *ICT* included, who cannot agree with some of their assertions, and certainly cannot agree with the conclusions.

The Group seem to have underestimated the effort that has already gone into the design of COBOL. The Executive Committee of CODASYL (Conference of Data Systems Languages) set up in May '59, created three committees to handle the investigation of Common Business Languages. The Short Range Committee, to whom COBOL 60 is due, covered nine different organisations who were represented by 14 people participating actively and attending most of the frequent meetings from June to November '59. During the last weeks they were in continuous session. Fourteen other people from these organisations, all of them again closely involved with existent auto-codes, at one time or another represented their organisations.

Paragraph 7 suggests that the COBOL designers lacked a knowledge of user requirements and produced basic COBOL without extensive study and under heavy pressure. The United States Department of Defense, regarded as the sponsors of COBOL, have over 400 computers in use and might well be expected to have a good idea of user requirements. Moreover, is it not a mistake to assume that because six of the ten organisations represented on the Short Range Committee were manufacturers that their members did not understand the problems of users? Computer manufacturers make considerable efforts to attract users and the punishment for not assessing user requirements accurately is heavy. *RCA*, *Minneapolis Honeywell*, *Sperry-Rand*, *Burroughs*, *IBM* and *Sylvania Electric* are not among those who have paid the supreme penalty. Regarding the pressures under which the manufacturers worked, the greatest was probably from users who were for the early design of a useful Common Business Language.

Since February '60 a COBOL maintenance procedure has operated under the supervision of two committees, one of which was composed solely of users (currently 12 members, including *Lockhead Aircraft*, *Chase Manhatten Bank*, *Standard Oil Co.* (*N.J.*), *General Motors*, *Allstate Insurance*, *US Steel* and *Du-Pont*). The present arrangement of the COBOL committees precludes the kind of difficulties anticipated at the end of paragraph 2 of the Appraisal. A special intensive session up to the end of 1960 tidied up COBOL to a state that could be "frozen" in a "COBOL 61." Whilst discussion and improvement proceed, all changes will be withheld for 12 months, during which time compilers can be constructed and programs prepared in COBOL 61. Improved COBOLS will then appear annually in which it is hoped all implementers will have participated.

There really is no problem of compatibility nor any need to define its boundaries. Few people believe that the changing of half a dozen words to enable a program to be acceptable to any machine is something to be accomplished in the next year. Nevertheless, this does not make complete compatibility any less valuable as a criterion against which any implementer can measure the cost of any variation. For example, the *ICT* COBOL includes a class "sterling" and associated features which were felt essential for British users. Because this makes for a degree of incompatibility, *ICT* will be anxious to line up with other British implementers, and to propose it as a feature for future international COBOL.

An interesting experiment was conducted recently in which a COBOL source program was translated on successive days by compilers on a *Remington Rand* and a *RCA* computer. The Department of Defense have not been able to translate all their COBOL programs on all their machines but they declare it extremely valuable to have all the programs related in a way which enables an exchange as between different dialects of one mother tongue rather than as between completely foreign languages.

Any suggestions (para. 3) that COBOL is orientated toward magnetic tape only is misleading. *ICT* in implementing COBOL have found no difficulty in catering for punched card files. Indeed, it is expected that the independence of the logical record from the in/output medium will be a great asset at the time when a user changes from a card to a tape configuration computing system.

If the criticisms of paragraph 5 are the worst that can be made of COBOL 60 then the language is surely "praised by faint condemnation" and one concludes that the really serious problems must have been met successfully by the COBOL designers.

Whilst full English tends to produce a bulky source program (para. 4) there are many advantages to be derived from an easily readable procedure description. *ICT*'s Rapidwrite offers the best of both worlds. Sets of cards are supplied preprinted with the fixed parts of the different verb formats, leaving the programmer to enter in the variables. The full English, however, is printed out at an early stage in compilation.

Many people are taking COBOL as a very serious attempt at a Common Business Language. *RCA*, *Remington Rand* and *General Electric* have written COBOL compilers; *Sylvania*, *IBM* and *ICT*, have issued manuals and *Burroughs* and *NCR* have expressed their intention to implement COBOL. *LEO Computers, Limited*, are preparing a language based on COBOL. The user of COBOL enjoys all the normal advantages of English style autocodes but in addition belongs to a family where exchange of programs and ideas is greatly facilitated and in which he has the opportunity of making contributions toward the goal of the universal computer language.

Yours, etc.,
P. V. Ellis

Computer Centre,
ICT Ltd.,
Putney Bridge House,
London, S.W.6.

Information Retrieval

Sir,

I do not know to what extent you publish news of members. If you do, the following information may save some other members from delays in correspondence as well as providing them opportunity for ribaldry.

From 1 April till the end of this year, I shall be on sabbatical leave from the Ministry of Aviation, as a Visiting Research Professor at the Center for Documentation and Communication Research, School of Library Science, Western Reserve University, Cleveland 6, Ohio, U.S.A.

I will be doing research into the mechanisation of documentation; in particular of "information retrieval". For some years the Center has been analysing the contents of papers, mainly in the field of metallurgy, preparing machine-legible forms of these abstracts, and experimenting with their machine manipulation for various ends. In co-operation with other institutions many types of computer are being used, but by February of this year the Center will have installed a modified GE-225. This is a transistorised general-purpose computer with 8192 word magnetic core store, made by the General Electric Company at Phoenix, Arizona.

Western Reserve University,
Cleveland 6, Ohio, U.S.A.

Yours, etc.,
R. A. FAIRTHORNE

DISCUSSION MEETING: PART II

THE CHARACTERISTICS OF COMPUTERS OF THE SECOND DECADE–continued

Reported by
Dudley Hooper

DR. BOOTH'S CONTRIBUTION

Dr. A. D. Booth, who was to have opened the discussion, was unfortunately prevented (by absence from the country) from being present in person. His comments on the paper were therefore pre-recorded and played back to the meeting.

His first and general remark was an old War Horse of his. "Miss Kilner starts by calling her paper 'An Account of the Characteristics of Computers of the Second Decade,' a title which I find quite unexceptionable, but, very shortly after this pleasing start, she goes on to say that she believes the paper to be a first attempt to make such a study of '*second generation* computers.' This of course is an implication that such second generation computers exist and, even after reading the paper, I feel that such claims are largely unjustified."

Emphasising that he was, as it were, acting as Devil's Advocate, so that he might not try to maintain all the points which he would make with such ardour on another occasion, he took up the point that, right at the beginning of the survey of computers of the first decade, that is up to 1959 by Miss Kilner's mode of accounting, she says that "two, or more, usually three, level storage is universal now for all computers" and this implies that this trend will continue in the future. It is always dangerous to predict, but talks with American colleagues led him to believe that they fully expect that the internal store will be wholly on magnetic cores or thin films. They seem quite untroubled by the expense of such large storage units and talk glibly of 30,000 words as being a store "of medium size." In this event it seems quite clear that most computers will have two-level storage: core and several magnetic tapes.

Miss Kilner then goes on, in the same section, to remark that one of the problems which has been highlighted in first generation computers is the lack of balance between the mechanical speeds of peripheral units and the high internal electronic speeds of the computer. This is, of course, almost a platitude and no one could disagree; however, it was by no means clear, to Dr. Booth at least, that any major break-through has been made in this field.

The distinguishing features of computers of the second decade is the next heading in the paper. We see the suggestion that computer speeds will now be measured in micro-seconds and milli-micro-seconds rather than in milli-seconds and micro-seconds as hitherto. The list of computers, both projected and commenced, which Miss Kilner gives, shows no evidence that arithmetic speeds in the milli-micro-second range are likely to occur—"at least if you are old-fashioned as I am and regard 250 milli-micro-seconds as nothing other than $\frac{1}{4}$ micro-second." It is, of course, true, as she says later on, that the limiting speed of a computer is likely to be set by the speed of light and may be of the order of 1 milli-micro-second for an addition. But no present computer seems to approach this figure by at least three orders of magnitude and, in fact, the figures given for future computing speeds are, to his way of thinking (supported by the original documentary evidence), precisely those which were suggested by the early pioneers in the field and, in particular, by the late John von Neumann. It is true that no such speed was achieved by an early computer, but the difficulties were those of detail and not of principle, and the electronic speeds which were legacies from the Second World War were substantially the same as those available today. No major improvement in, for example, electronic valves has been made in the past fifteen years. The transistor is a temperamental beast for which claims have been made, appearing to have no basis in fact. It will do many things to computers, but, at the present time, it is difficult to see that it is going to produce a speed break-through greater by three orders of magnitude than the speeds attainable with electronic valves. Present transistor technology seems to produce computers of about the same speed as could be produced by valve techniques had they been pressed to their natural limit.

The main platform upon which most "seers" praise the machines of the future seems to be that they are likely to provide facilities for interrupting the running of computer

programs when programs of higher priority become available. Actually such ideas are quite old, they were discussed by pioneers long before computers were actually in operation, but they have only assumed importance since computers have evolved from the university stage to being practical tools in commerce and industry—a pure matter of economics and not of principle. In the same paragraph of her paper, Miss Kilner suggests that the operation of machines will no longer be held up by the slower operation of peripheral units and she says that it will no longer be necessary to limit their number.

"Now, speaking as one of the earliest workers in this field, I can say that in the case of my own machines and, I believe, in the case of most other early machines provision was made for the attachment of a large number of input and output devices." The reason that these were never added to the machines was more the cost and intrinsic unreliability of such equipment rather than any limitation imposed by the computers themselves. To say that the new computers will have much peripheral equipment, whereas the old ones did not, is not to say that there is any real difference between the machines. In fact the additional equipment is justified merely because the new machines are to be used in commercial data processing.

Turning to the subject of concurrent operating techniques, "I would first make a minor remark which is that, to my mind, the idea that multiple programmings are in any way different from various branches of a single program is erroneous and is a consequence of the subliminal advertising which replaces critical thought at the present time. Those of us who thought in detail about the ways in which computers could be used to interrogate different input stations in the course of their operations had clearly envisaged that this would be done by means of either stored or wired-in programs. Such programs would be many-branched, but would sometimes execute continuously one branch which was, in fact, a self-contained entity. How this differs from being one of a set of completely distinct programs is a logical subtlety which completely escapes me."

When Miss Kilner comes to a discussion of the methods by which time sharing is to be achieved, the point of the greatest interest is that of error detection and correction by the machine as a result of several trial attempts. There is not much which is new in principle here, but the practical application of such correcting techniques will mark a new departure.

In the short section on the "Advantages and Disadvantages of Time-sharing versus Multiple Control Techniques" a point is raised which must not escape comment: why does the French machine have such a low basic cost, whereas some British machines, which do not have quadruplication of control and arithmetic units, are likely to cost three or four times as much? It is time that certain British manufacturers sold their wares at realistic prices based upon production costs and not at national figures depending upon "what the traffic will bear." Naturally research and development costs have to be covered, but the British taxpayer is often the sponsor for these and any alleged deficiencies are due to incompetence or worse.

In the section on "Advantages and Effects of the use of Parallel Programming Techniques" the question "Will the small computer be put out of business by large machines using these techniques?" is posed. As a member of a university which has both small computers in such departments as his own and a large central computer available to all colleges and departments, Dr. Booth considered it clear that both classes of machine have certain definite advantages. When large and complex calculations have to be performed the big machine has it every time, not only for efficiency in pure computing but also in ease and economy of central maintenance. When, however, the problem of training students arises, the situation is rather different. For example, in the University of London a student prepares his program, usually in autocode, and presents it to the machine, or rather to the machine operator. From this point two or three things can happen. The program may run first time, but usually the machine refuses to accept the program and, although sometimes the autocode detects an error in the man's original coding and provides some check indication which is in due course given to him, in many cases of a less simple kind the program is accepted by the machine but refuses to run. At this point the student is given a bald statement that the program does not run and is sent back to his parent institution to find out why. This may perhaps be attributed to a bad autocode or to unhelpful personnel at the central unit; Dr. Booth did not believe this to be the case, but an inherent defect of a system of this kind.

What he had found far more satisfactory is for the student to run his early programs on a small machine where time is sufficiently inexpensive so that he can sit down at the machine console and, upon his program failing to run, follow it through on the control panel.

He thought, therefore, that in the future the large machines will take over all real calculations, however small, but that small machines will still be needed in teaching institutions for the direct use of students.

In a later section of the paper some so-called distinguishing features of individual computers of the second decade are mentioned, for example, the new fixed store consisting of woven copper mesh into whose spaces can be fitted tiny rods or slugs of magnetic material to raise the mutual inductances between wires. Now, such a device is already in operation at the Institute of Precision Mechanics in Moscow and the idea of increasing the "communication" between two sets of wires by some method is very old. "I myself, whilst at Princeton in 1947, devised and tested a matrix of copper strips between which was placed a sheet of perforated paper which contained the program or other data for the machine. The effect of the perforations was to vary the capacitative coupling between the conductors. This from the 'idea' viewpoint is in no way different from the use of magnetic slugs except that (*a*) it is much simpler, and (*b*) it has the advantage that the paper sheet can be retained, whereas it appears that the arrangement of slugs must be broken up if the program is altered.

"Another suggestion of a novelty seems to be in facilities for mixed radix working. This idea is really quite old and one of my students, Ralph Townsend, wrote a thesis in 1953 which described an arithmetical unit which he had constructed to do precisely this. His arithmetical unit was tested on a machine completed in 1952."

Many good points are made in the section which discusses peripheral equipment. Dr. Booth's personal opinion was that the most important ancillary is the magnetic tape, with the "juke-box" store as a close second. Such things as character readers are very good for specific applications but are not yet developed to the stage where they can handle real problems which involve arbitrary type founts and, most important, sheets and pages of data. The high speed paper handling which is involved in reading a book by electronic

means is a mechanical problem whose solution is by no means trivial and has, so far, received scant attention.

And now, finally, the "Future Outlook in Computers." He hoped to see something new, but the suggestion that micro-wave techniques to provide the means of bridging the gap between the micro-second and the milli-micro-second is new is quite unwarranted. Von Neumann was suggesting precisely this application of micro-waves in 1946 and his independent invention of the "Parametron" was a direct consequence of this approach. The reason that no machine of this type was built at that time was certainly not that the techniques were not understood, but rather that the ordinary difficulties of electronic hardware construction had yet to be overcome.

"To sum up my own feelings in regard to the immediate future of computers, I would say that the position seems to me to be one of consolidation. Such new machines as are produced will use new production techniques and old logical and circuit tricks to solve specific industrial and commercial system design problems. There is still outstanding the most important problem in computer design: to discover how to make an efficient, cheap, and compact large scale store, and to this I see no prospect of a solution."

VIEWPOINTS OF THE MANUFACTURERS

In the second session of the meeting, representatives of eight computer manufacturers each replied to various points made by Miss Kilner or Dr. Booth. Most manufacturers had issued notes on their computers to those attending the meeting.

Mr. P. V. Ellis (*International Computers and Tabulators Ltd.*) stressed that the choice of features to be provided in a computer was largely an economic one. The ICT 1301, for example, was designed for high speed, with a high duty cycle throughout the machine and also throughout the range of expected applications. The computer apportions its time and there are no buffer stores.

Mr. H. G. Mitchell (*Elliott Brothers* (*London*) *Ltd.*) gave the ELLIOTT 502 as an example of a machine with real-time working. Solid state components give high speeds, the speed of the computer being limited by the speeds of peripheral devices; time-sharing allows the computer *not* to have to wait. Very high overall computer speeds increase the number of possible applications. He also gave details of the 802 and 803.

Mr. G. Felton (*Ferranti Ltd.*) suggested that many points in the paper would be difficult for the "business user" to understand; the user should not be concerned with the design of the machine, but only with its overall ability, speed, ease of programming, physical requirements (maintenance, building, etc.) and cost. He felt that there was still some confusion of thought and definition on many aspects of "parallel programming." Space-sharing (e.g. of the store) is as important as sharing time.

Dr. H. D. Aspinall (*IBM* (*United Kingdom*) *Ltd.*) took issue with Dr. Booth; there was a vast difference between thinking of an idea which could be made to work in the laboratory, and turning this into a production model. He then read a paper on the *IBM* range of machines.

Dr. J. M. M. Pinkerton (*Leo Computers Ltd.*) endorsed what had been said by Mr. Ellis, and felt that time-sharing helps to make the fullest possible use of the machine, with no part idle if avoidable. For example, an adding unit can be used for both adding and modifying; why, then, have more than one adder. He thought the trend would be to larger stores, but it is necessary to reduce the number of times of going to the store, to leave the "doorway" freer. Macro-programming helps the designer to introduce facilities otherwise impracticable. He went on to deal with several aspects of time-sharing; it is necessary to distinguish between program priorities as a whole, which need to be programmed, and priorities as between on-line facilities, which need to be automatic (e.g. for unloading when ready, to avoid loss of information).

Mr. M. A. Anderson (*National Cash Register Co. Ltd.*) suggested that automatic interruption by peripheral devices was feasible for larger machines, but might cause difficulties in design. He agreed that such interruption should be automatic for off-loading.

Mr. G. Davis (*English Electric Co. Ltd.*) disagreed with Mr. Felton's contention that the user should trust the manufacturer! It might be rash to rely on a manufacturer's statement that a machine would do a particular job, and the user must understand something of how the machine works. He did not accept Dr. Booth's comment that the principles of concurrent operation were "old hat"; what was new was that these techniques are now being put to use, and not just being played with. He suggested, however, that time-sharing is being over-written; at one time one can only do several jobs if there are enough storage and peripheral units, which may be expensive, while they all have to share the same doorway to the store, so that access time is the vital point; there is a tendency to cram everything on line, instead of using ancillary devices.

Mr. E. J. McGubbin (*EMI Electronics Ltd.*) held that time-sharing for a medium system (with not too many peripheral units) is best done by each input-output unit having its own buffer store. This also simplifies maintenance. Finally, he could not accept Dr. Booth's implication that the new computers are non-existent; a number already make use of the techniques described by Miss Kilner in her paper.

GENERAL DISCUSSION

Opening the first session of general discussion, with a panel of manufacturers' representatives on the platform, Mr. C. Strachey emphasised, speaking especially to potential users, that there is much more to a computer than its hardware. Writing programs can be as expensive and is certainly time consuming. All the new machines discussed are large ones and more powerful than those to which users are accustomed at present. They are likely to consume programs and programmers with remarkable rapidity, needing a programming effort on a greatly increased scale. In America manufacturers generally have organised service programs for interpreting, debugging, etc., and a similar series of programs that communicate back to the programmer in language he understands will be required for these new machines. Have manufacturers in this country devised such super-

visory programs, are they really planned, or are they just pious hopes? Time sharing must be automatic, and not left entirely to the programmer.

In reply, Mr. Felton said that *Ferranti* have not finalised supervisory routines for ORION or ATLAS, but they are now working on these; there are many problems. Mr. Davis said that for the KDP 10 a range of automatic programming schemes exists, while for the KDF 9 the system has been broadly mapped out. No programs have yet been written for the EMI 2400 but, Mr. McGubbin explained, programs of this nature will be written for particular circumstances. Dr. Page (of *AEI*) said that housekeeping routines have been written, tested and were running for the AEI 1010, but there will be a number of such routines needed for different configurations of system, and these will be written as required. Mr. Mitchell stressed that on the ELLIOTT 503 no supervisory routine exists but the machines will be limited to two levels of priority, so that simpler routines only will be needed; the 502, a real-time machine, will need routines tailored to fit each application.

Mr. Anderson explained that the NATIONAL 315 is a simple machine and does not require time-sharing programs, but there will be monitoring routines. Mr. Dreyfus dealt with the special features of the GAMMA 60, pointing out that on this machine concurrent programming is done by providing extra hardware, so that no special supervisory programs are necessary. Machines of this type are now running with concurrent operation, such as program debugging while running, say, tape sorting problems. They can also do conversion from one medium to another while printing, for example. There are monitoring programs, however, for determining, if one routine fails, for example, the cause of the error. Dr. ApSimon said that the IBM technique SOS is now on field test, being nine-tenths complete, while the STRETCH supervisory program is being tested in the United States; it will be a few months yet before it is fully working. Mr. Ellis, referring to the ICT 1301, explained that on this machine it is not possible to have concurrent programs for separate jobs; a COBOL compiler is to be written, and is expected to be completed in about nine months. Mr. Pinkerton, referring to LEO III, said that supervisory programs have not yet been written but their aim is now known and their importance realised; he thought that one or two years will be needed to develop them. Mr. Anderson added that an assembler/compiler will be provided with the NCR 315, which will check for errors; a COBOL type compiler will also be provided.

Dr. Yates, from the chair, underlined Mr. Strachey's remarks and expressed his own opinion that, if time-sharing is to be useful to a user, it must be carried out by the machine and make no demands on the user. The operator should be able to put in any miscellaneous program at any time, the machine handling this without action by the programmer. He asked if manufacturers had any comment on this thought.

Mr. Page, in reply, said that time-sharing supervisory programs for the AEI 1010 put no onus on the programmer to decide where his program is to go in the store, etc.; housekeeping routines will sort this out, provided peripheral equipment, etc., is available. The user must present to the computer information as to the amount of working store, backing store, number and type of peripheral units, etc., required, and the machine will then accept the program or reject it. With four or five high-speed tapes, the machine can be loaded so that a number of concurrent routines can be operated.

In connection with the problems of storage space, Mr. Dreyfus stressed that one must differentiate between concurrent operation of separate production routines, and debugging a program under a monitoring routine and doing production work somewhere else in the store, for example. The monitor can check allocation of storage. When running a debugged program it can still happen, however, that a particular piece of data may cause a wrong address to be computed and thus the routine being processed will jump out of the allocated store. The probability of this is low and can probably be tolerated. When using the computer for debugging one program while another is running (which he suggested would be unusual) one should let the running program over-ride the other.

Mr. Strachey emphasised that one must not over-simplify the problem of debugging programs; residual program errors do persist for a long time, and this difficulty of overflowing storage will arise. Mr. Davis said that many systems have some supervisory routine, with hardware, to guard against the overlapping of store allocations; this is a part of the design requirements. Most manufacturers with time-sharing machines realise the necessity of not putting the onus on the programmer to see that he does not infringe the space occupied by other programs. Mr. Dreyfus suggested that store contents should be dumped onto magnetic tape every minute or so, so that in the event of clash nothing would be lost. Dr. Yates questioned how, in this case, one knew which of, say, four jobs has transgressed if a transgression has occurred. Dr. Tocher suggested that there is an even worse possibility: a program that appears to be a transgressor may have itself transgressed because of an error in another program that has modified the apparent transgressor.

From the floor, a questioner asked if, when concurrent operation is controlled by hardware, the machine would effectively indicate if two programs are incompatible. The reply generally by manufacturers was that this will in fact be so, but Mr. Gosden (of *LEO Computers Ltd.*) emphasised that doing a number of jobs together is not the main problem. He considered that time-sharing has been oversold by engineers; the overall efficiency of a machine is not the 90% or so claimed for operating efficiency, but the total operating time available after allowing for all errors of operators and programmers, data handling, and unloading and reloading the machine for another job. It is here that time-sharing will allow spare routines to carry on so that the machine will not be idle. He went on to make the point that if a programmer uses autocodes, these impose a standard of discipline on all programs, which must be in standard routines, and which will all look alike to operators so that the machine has no idiosyncrasies to deal with.

Another speaker suggested that the operator should be considered; it might even be necessary to have separate consoles for different programs to avoid a mix-up on the console when several routines are running at the same time! Mr. Dreyfus emphasised that concurrent operation must be considered as space-sharing. There are some physical limitations on the programs that one can run together, as the peripheral equipment must, in practice, be linked to a specific program. Each operator therefore runs only the peripheral equipment which his program needs, and one console can therefore suffice; a supervisory typewriter can print information for each operator. Dr. Page stressed that the console should be the supervisor's concern, with separate operators handling the peripheral equipment.

Some discussion centred on the note in Miss Kilner's paper

on visible record equipment; the need of business users was emphasised, especially for printed output to give historic data in visible form behind the updated information held in the system. Other speakers stressed that there is, in practice, no difficulty in maintaining suitable records with a conventional punched card system. Magnetic tape can do the job in just the same way, provided the rules for printed output can be stated; this is a job for systems people.

* * *

In the second afternoon session (held as an extension of the discussion at the request of those present) Dr. Tocher (taking the chair in the unavoidable absence of Dr. Yates) said that he appreciated Dr. Booth's feelings as a pioneer that no ideas are new, but he was not entirely in sympathy with his remarks. Perhaps we are not quite ready for the application of some of the new ideas and we may be rushing their introduction before customers are ready for changes in programming habits and understanding.

Mr. Glennie (of *UKAEA*) said that SOS has been on field test for some months and wondered whether such programming systems will be ready before the machines become obsolete. He also wondered if such programs will be able to be accommodated on the machine, as they require a large amount of storage. Dr. ApSimon admitted that development of program systems takes a very long time and he appreciated the help which *UKAEA* had given in developing SOS.

A speaker from the floor stressed that it was very difficult, for business men particularly, to assess the capabilities of a computer without seeing it in operation. The best way for manufacturers to achieve this would be to use their own machines in their own organisations. Manufacturers' representatives generally said that they were using earlier machines happily and efficiently in their own organisations; Mr. Felton suggested that if a computer was working it was obsolete!

A questioner asked if manufacturers were really suggesting the use of these large machines for the ordinary commercial bread-and-butter job. Would one want more than one such program operating concurrently? Mr. Felton thought that commercial customers would, in fact, use time-sharing machines; the systems being installed envisaged one main job being run with several small ones (such as card/tape conversion, printing from magnetic tape, etc.). Mr. Ellis stressed that time-shared machines are being bought, Mr. Anderson confirmed that *NCR* machines were being specifically designed for bread-and-butter work, while Dr. ApSimon suggested that it was very rarely that an installation had only one job and therefore time-sharing was surely important. Dr. Pinkerton added that even some so-called bread-and-butter jobs needed very powerful equipment; time-sharing features would be most useful and not necessarily proportionately expensive.

Another speaker suggested that it was wasteful having so many manufacturers each separately designing machines. In the end the user is paying for this duplicated design effort. Several manufacturers admitted that there were probably too many manufacturers of computers, but one suggested that there might be difficulties with the monopolies commission if amalgamation went too far! A further point made by the same speaker was that new machines should be compatible with the older ones and that there should be faster development of automatic programming techniques; manufacturers should take COBOL more seriously. Mr. Felton replied that new machines will accept old programs to an increasing extent, largely through common language systems, while Mr. Ellis suggested that if it is economic to write translation programs from the code of one machine to another, then these translations will be written. There have been many meetings of manufacturers on this question of a common language; it is generally felt that if COBOL or any other standard language is adopted now, there is a risk of designing machines round the language, which will be too restrictive. Others consider, however, that if we don't start with a common language now, where do we go and when do we start. Mr. Anderson stressed that unless an autocode was perfect it should surely not be perpetuated, while Dr. ApSimon said that on the question of compatibility it was sometimes possible for a manufacturer to design a sequence of computers which had compatible features.

In further discussion, a speaker suggested that perhaps it was being overlooked that it should not be beyond the capabilities of manufacturers to devise diagnostic routines to test programs and ensure that they do not infringe on one another's rights. But he questioned the advantage of one large machine, which will do, say, four jobs, over a number of small machines, each costing, say, one quarter the price of the large machine, each doing one job; there was the important aspect of breakdown. He felt that the importance of time-sharing lay in integrated work. Mr. Felton suggested that diagnostic routines in principle are not possible without the use of interpretive routines, which are too slow. As to the cost of machines, his experience was that the computing capacity goes up as the square or cube of the price!

The last speaker from the floor accepted that it would be possible to devise means of locking out programs when necessary, but wondered what control there would be over the human danger of operators using the wrong units or the wrong tape reels; could this be under program control or be prevented by automatic warning systems? Dr. ApSimon said that this sort of problem has been tackled on STRETCH, while Dr. Pinkerton wondered whether there was a need for some sort of literal lock-out system (such as a Yale key)! Mr. Felton stressed that in a well-designed system tape reels would be identified by a block of identifying data at the beginning of each reel which would have to be recognised by the main program before the reel contents were accepted.

ELECTRONIC COMPUTER EXHIBITION, 3–12 October 1961
SYMPOSIUM ON ELECTRONIC DATA PROCESSING, 4–6 October 1961

New Story of Management

"Advances since our last exhibition in 1958," said Mr. A. G. Coaten, chairman of the organising committee, announcing plans for the 1961 exhibition to be held at Olympia, London, "have given us a whole new story to tell. Our aim is to bring it to the attention of management from all over the world."

In the past three years, he said, four major influences had been at work. These were:

(1) In "hardware," there had been fundamental advances ranging from the use of transistors and new storage devices to much faster printing mechanisms.
(2) In "software," there had been simplified programming coupled with improved service and training facilities.
(3) Maintenance had been revolutionised by replaceable printed-circuitry packages, and reliability of machines had been greatly increased by automatic self-checking devices.
(4) Time and money spent on research, reinforced by a feed-back from the ever-widening experience of users, had resulted in the availability of computer systems which offered flexibility and expansibility to meet the needs of management in organisations of every type.

"Our exhibition will show," he said, "that in 1961 the small and medium-sized business has at its disposal unit-built computers designed to do the right job at the right price, and ready for expansion when necessary.

"We shall all be very proud of the new machines that we have on our stands, but the only justification of all this equipment is the greatly increased information and management control services which it is able to produce for users. That is what the exhibition is about."

Earning with Computers

Plans for the Symposium on Electronic Data Processing, to be held at Olympia on 4, 5 and 6 October, were announced simultaneously by Mr. G. W. Cushing, chairman of the symposium committee.

"The important thing about the sessions of these three days," he said, "is that they will belong to management. They will all be concerned with the general subject of earning with computers. By this I mean that the time will be devoted not so much to the mechanics of individual jobs such as pay-roll and stock control as to the methods that are being devised to achieve more efficient use of capital, taken in the widest context.

"Businessmen who have so far had no first-hand experience of electronic data processing can come along to Olympia and learn what it is like to live with a computer in a number of different industries. Those who already have experience will have much to offer in the discussions and I expect the contributions from the floor to be as valuable as those from the platform.

"On the first day, under the heading *Then and Now*, a number of users who spoke in the 1958 symposium will explain the advances that have taken place since that time.

"On the second day a selection of speakers from various industries will detail the work of preparation and installation of up-to-date electronic data processing systems.

"The third morning will be taken up by a Brains Trust in which a number of small users will describe the benefits they have obtained from service centres.

"On the third afternoon, two or three of Britain's leading authorities will present papers setting out some of the techniques which are just around the corner and will outline how they will be applied."

Further advance particulars will be published, as they become available in *The Computer Bulletin*, Vol. 5, Nos. 1 and 2.

THE SELECTION AND TRAINING OF COMPUTER PERSONNEL

Owing to pressure on space the report of this meeting has been held over. A review of the papers and discussion will be given in the June issue of *The Computer Bulletin*.

THE RELIABILITY OF MECHANICAL ENGINEERING PARTS OF DATA PROCESSING SYSTEMS

Reported by Miss D. P. Kilner

Synopsis

1. An informal discussion under this title was held on 5 January 1961 at the Institution of Mechanical Engineers.
2. To provide a logical pattern for discussion the meeting was divided into three parts.
3. It was anticipated that realistic data on mechanical performance and suggestions for overcoming its deficiencies would be forthcoming.
4. The general thesis before the meeting was that the standard of reliability of the mechanical engineering parts of data processing systems were 10 to 100 times below that now required by users and that there was a general disparity of reliability between the electronic and mechanical parts.
5. Reliability was taken as the percentage availability for use when required within given tolerances.
6. The standards required of the mechanical parts of data processing systems were at least one, and perhaps two, orders of magnitude greater than is required for many other mechanical machines.
7. The great emphasis frequently placed on the electronic aspects of data processing tended to obscure the fact that these systems have a high mechanical content.
8. What is a mechanical failure?
9. The causes of failure of the mechanical parts of data-processing systems were two-fold: those relating to the mechanical engineering industry as a whole and those of particular consideration with regard to computers.
10. There was a lack of harmony in the overall design.
11. Manufacturers of mechanical parts were not thought to appreciate the background against which their equipment was to be used: *wear*.
12. The reduction of repair time.
13. The fragmentation of the engineering industry as a whole and the disparity of quality of the mechanical and electronic engineers.
14. Plea for establishing data processing engineers *per se* and other remedies.
15. Contributions to solution already being made by manufacturers of peripheral equipment.
16. Other suggested remedies of a technical nature.
17. Finally, a plea for more co-ordinated research in the data-processing industry as a whole.

Note: The Society's representative has drawn on the material provided in the printed abstracts. Due acknowledgement is hereby made to the Institution of Mechanical Engineers.

* * *

An informal discussion under this title was held on 5 January 1961 at the Institution of Mechanical Engineers, under the aegis of that body and the British Conference on Automation and Computation.* It may be regarded as a sequel to that held on 21 March 1960 on *The Computer in Production*, also organised by the Institution of Mechanical Engineers, but it also harks back in spirit to an earlier (20–21 January 1960) two-day programme organised jointly by The Institution of Electrical Engineers and The British Computer Society Ltd. (again under the aegis of the British Conference on Automation and Computation) on *Reliability and Maintenance of Digital Computer Systems: Managerial and Engineering Aspects*. Towards the close of this programme there was a strong attack on the weakness of the present mechanical and electro-mechanical peripheral units, one speaker going so far as to call for a joint meeting of the Institutions of Electrical and Mechanical Engineers under the title: "Why are the mechanical parts of a computer one hundred times less reliable than the electronic parts?" There was in fact a general feeling that it was here that improvement in reliability should first be made.

To provide a logical pattern for discussion the meeting was divided into three parts. The morning session was devoted to consideration of the present position and the fundamental problems of kinetics associated with mechanisms operating at high speeds. The afternoon and evening sessions were entitled *Computers and Other Electronic Equipment* and *Peripheral Equipment* respectively, and here the production of electronic equipment and allied precision mechanisms were discussed. About 150–200 delegates attended these sessions and speakers included representatives of both users and manufacturers.

It was anticipated that realistic data on maintenance and comparisons between the performance of electrical and mechanical constructions would be forthcoming, and that peripheral equipment would also figure largely in the programme. In the early history of computers such equipment was based upon modified designs of already established office machines, but it was soon recognised that some fundamental development was required in this connection if the potentialities of the computer, especially in respect to speed of operation, were to be fully exploited. It was hoped that the meeting would provide an opportunity of discussing means of overcoming these existing limitations of a mechanical character.

Relative Reliability of Mechanical and Electronic Equipment

The general thesis before the meeting was that the standard of reliability of the mechanical engineering parts of data processing systems were 10 to 100 times below that now

* The papers and the discussion will be issued in the full proceedings, to be published later by the Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

required by users and that there was a general disparity of reliability between the electronic and mechanical parts. This was accepted as being true, although one or two speakers contested that this type of equipment caused only about half of the errors experienced, and that this in itself was an achievement since it was more difficult to establish reliability in equipment with moving parts than in equipment without. One could say, with this in mind: why is the electronic equipment not even higher in reliability since this is less difficult to achieve? Another difference was that electronic faults could be anticipated and their incipient failure known, but this was not so with mechanical faults, which, when they did occur, resulted in a much greater loss of machine time (a proportion of 10 to 1 was given). Reliability, in this context, must not only indicate a very low breakdown rate but also very small periods of time required both for routine maintenance and for repair. The thesis lead naturally to considering the questions: what are the standards of reliability required? what is a mechanical failure? what are the causes of mechanical failure? Discussion ranged round these in general terms and in particular relation to computers, with solutions proposed that related to the mechanical engineering industry as a whole, as well as to the production of data processing systems.

Reliability was taken as the percentage availability for use when required within given tolerances. It would be unrealistic to expect perfect accuracy always; it was never complete and 100% availability had to be maintained using aids to reliability, including (*a*) self-monitoring and fault-indicating features and (*b*) standby equipment, if necessary, with automatic changeover. The cost of maintaining this availability in these ways was high, a figure of £5,000 per annum, for a £35,000 installation being given. It was evident that reliability was more important than computing speeds, for in itself it greatly affected the overall speed of operation as well as its cost.

The standards required of the mechanical parts of data processing systems were at least one, and perhaps two, orders of magnitude greater than is required for many other mechanical machines and particularly for the more normal uses of these machines which are established for office and telecommunications applications. Why were these high standards required by computer users? The first reason was the vast volume of data which computers must handle, then the very high speeds at which it was handled and finally the high usage factor required from any data processing installation, this sometimes being 24 hours a day. Expensive equipment could not be allowed to be idle. Furthermore computers could not distinguish, as a human being could do, between important and unimportant errors; unlike human beings also it could not usually cope itself with errors in its own input data. Again, mistakes in computers were usually remote from the operator, difficult to find and put right when they did occur.

Effects of Environment

The great emphasis frequently placed on the electronic aspects of data processing tended to obscure the fact that these systems have a high mechanical content. The electronic equipment itself involved a number of important mechanical considerations, e.g. electrical connections, design of components, assembly and mounting arrangements which facilitated maintenance and ensured adequate ventilation for the dissipation of heat from components. There was a strong effect on mechanical design of the relationship between the computer and its environment. These environmental conditions affected the serviceability of the computer through the agency of: (1) Temperature, (2) Humidity, (3) Dust and (4) Vibration. Proper serviceability therefore depended on proper environmental control, in particular on the solution of the heat exchange problem. This problem had not been necessarily solved by the introduction of transistors, for miniaturisation and transistors together in the new designs produced counter-balancing effects: the amount of heat produced per circuit had gone down but the number of circuits in a given space had gone up, so that there was little change in the amount of heat actually produced per cubic volume. Even in cryogenics there was still a heat exchange problem. Reduction of noise and vibration was also important as ADP equipment was frequently installed in offices. Furthermore noise and vibration were frequently indicative of excessive wear and tear and lower noise level was conducive to higher efficiency and reliability among the operators.

Causes of Mechanical Failure

The strong incidence of mechanical failure lead to the question: what is a mechanical failure? In equipment, where there was so much overlap between the different engineering domains, almost any failure could be called a mechanical failure as it affected some material part, but it may not have come within the province of the mechanical engineer. In general, electrical failure was always preceded by a mechanical failure of some sort. An electronic valve might lose its vacuum, a transistor seal failure might allow moisture to enter and contaminate the crystal structure, a soldered joint might be dry, a spring contact weaken or even a wire just fall off! Even printed circuit cards were weak and their successful attachments and interconnections, however made, depend on discipline in putting them together. A fault might be called a mechanical failure when it could be due to faulty electrical or electronic design.

The causes of failure of the mechanical parts of data-processing systems were twofold: those relating to the mechanical engineering industry as a whole and those of particular consideration with regard to computers. As a consequence the solutions to the problem suggested also came more or less under these two heads.

There was a general lack of harmony in the overall design of such systems. Very close liaison must be maintained between mechanical and electronic engineering designers to ensure that boundary problems involved in connecting the mechanical and electronic equipment were simplified and standardised as much as possible and solved in the best manner. The relative merits of performing certain operations electrically or mechanically also needed to be carefully assessed to ensure that the more reliable method was adopted. The design should be functionally complete, e.g. where paper feed attachments on printers were to be permitted alternatives, these should be designed and tested in conjunction with the main printer at the outset. Any subsequent attachments which might be evolved must be tested in conjunction with the main machine to verify that the overall performance was satisfactory before they were permitted to be used. Commercial pressure to extend the speed of operational equipment should be resisted unless an adequate period was given to enable designs to be fully tested and validated by comprehensive laboratory and field trials. In fact, reliability of the

system treated as an integrated whole must be a basic design objective and must be conscientiously sought throughout the whole course of design, production, inspection and testing procedures.

The Stresses on Components and Materials

Manufacturers of the mechanical parts were not thought to appreciate the background against which their equipment was to be used: the demand for regular and continuous operation and the tight turn-round time in much commercial work. In some cases it would appear that the basic material and design were not suitable for these exacting conditions leading to over-stress and fatigue, and it was ventured that by far the commonest cause of breakdown was simply *wear*, with which must be coupled progressive maladjustment due to vibration, etc., giving rise to occasional spurious operations under certain combinations of adverse circumstances. Wherever possible, of course, problems of wear should be avoided altogether; contact-making cams and direct contact brushes could often be replaced by electro-magnetic or photo-electric pick-up arrangements. It was also fundamental that any adjustments which might be provided for taking up manufacturing tolerances and wear should be simple and readily accessible.

Inaccessible Mechanisms

The reduction of repair time for mechanical equipment would also be a fruitful field of study. All too frequently the part to be repaired was so inaccessible that a large section of the equipment had to be taken down before the repair could be effected. It would be of enormous advantage if the equipment were always to be of unit or modular construction. Unlike electronic equipment, no techniques existed for giving warning of impending failure. The introduction of such techniques on peripheral units would confer very obvious benefits. Cleaning and lubrication still typically demanded long periods of time. The use of sealed or plastic bearings throughout would cut the maintenance time on current equipment by at least one-third and in some cases by one-half. It was also stressed how much the actual operating and maintenance staff themselves affected the reliability of a system and how important it was that they should have adequate training and tools for their work. The ideal system should, of course, have no preventive maintenance at all.

Educational Problems

It was suggested that the fragmentation of the engineering industry as a whole was a grave cause of the lack of cohesion in designs. Some co-ordination must be established between engineers from different disciplines who were working on the same systems. It was also suggested that the quality of mechanical engineers did not in general reach that of their electronic counterparts, and that there was not the same vitality as in the electronic teams. One cause of this was a failure to provide suitable education (they were usually trained in heavy engineering, not in small, complicated mechanisms) and another to provide suitable rewards, or even facilities. There was also a lack of good actual designers in this field; actual product and production design were subjects not discussed nearly enough. The whole mechanical engineering industry was felt to need a more dynamic and ambitious approach; there was not, for example, nearly enough co-ordinated basic research in this type of work, leaving the industry far too dependent on the results of USA work. The use of soldered or wrapped joints, or taper-pin connections, for example, was of the essence of reliability and yet there was no basic research in this country on that problem. Another cause of failure might be in the way a mechanical engineer tended to work: an electronic equipment was usually an assembly of specialised components bought out for insertion into the design, but the mechanical engineer tended to follow the reverse procedure and make everything himself. Neither did he use instruments enough in making or testing his designs; in particular he did not make the fullest use of high-speed recording techniques in the examination of mechanical equipment.

Apart from the solutions to the problem already hinted at: the greater co-operation required in the engineering industry leading to more co-ordinated designs and production, the greater communication between manufacturer and user in ensuring optimum designs, the reduction, if possible, in the number of moving parts and consequently of wear, with also the infiltration of electronic techniques in place of mechanical ones, the reduction of repair and maintenance time, the possible use of modular units in mechanical parts, leading to mechanical sub-assemblies and unit-construction, the introduction of techniques for giving warning of failure in those parts, the importance of adequate staff, better training and more research within the whole industry; others were suggested. Most profound among these was the plea for the establishment of data processing engineers *per se* for the computer industry as a whole. It was suggested that we had something to learn from the Germans in training engineers to work on the smaller, intricate mechanisms and also on the employment of men of much higher qualification for this work. The mechanical man could learn from the structural engineer as well: his principle was that his structures must be *calculable* before being elegant; a dynamic structure must also be *calculable* first.

Design Improvements by Manufacturers

It was claimed that the manufacturers of peripheral equipment were already contributing to the solution of the problem: by studying ways of reducing the number of moving parts, by reducing the inertia of moving parts, by the use of new materials, by increasing the electronic content of mechanical parts, by extensive field trials and the feedback of results. But it was also claimed that the continual demand for higher operating speeds concealed these design improvements. It was also pointed out that computer manufacturers were already, through their trade association, the Electronic Engineering Association, striving to reach mutually acceptable standards which would help to restrain the excessive variation of equipment which made production and design so difficult. The strain of meeting continually increased demands for speed might be alleviated by the new concept of time-sharing in computers, whereby their operational flexibility would itself lessen the need for high-speed working in individual units.

Nevertheless other suggestions of a technical nature were still made: the use of the worst-case concept of design, in which the circuit must still work even when there is a combination of worst things happening to it; the avoidance of mechanisms which suddenly start or stop, the considerations of accelerations and decelerations, the use of kinematic design, and the development of improved transducers. It

was suggested also that as the mechanical units of a data processing system do not amount to much above 5% of the whole cost, the price of this equipment be quadrupled, the extra money being spent on achieving higher reliability, since even this would not jeopardize the marketing of the whole system.

Need for greater collaboration

Finally, a plea was made on behalf of the data-processing industry as a whole, including its electronic and mechanical domains. The effort and costs required for research and development of data processing systems on a continuing basis was considerable and could not be afforded by many. The number of competent designers in this field was relatively few and it was worth considering whether these were not spread too thinly in an industry where the rate of technological advance was so rapid. Greater concentration and collaboration on particular fields of development might well be essential in the interests of economy, progress and reliability.

THE AUTOMATION OF AN ELECTION

by B. Higman

Some months back, the writer became one of the "appointed" members of the committee of the Social Club associated with the laboratories in which he works. One of the items inherited from the retiring committee was a proposal to abandon the system of "Proportional Representation by the Single Transferable Vote" (PRSTV) in choosing the "elected" members of the committee. As the writer—in company, it appeared, with most of the committee—was largely ignorant of the workings of this system, some fairly meaty homework was indicated. This coincided with a second piece of homework, namely, to learn about ALGOL and to acquire some facility in its use. The temptation to combine them was irresistible. The result was tested on the papers of a previous election, giving complete agreement with results of counting by hand. But whereas the Returning Officer had estimated that ten man-hours had been taken up by the hand count, the computer count took under half a man-hour each for the three processes of transferring the votes to tape, checking the tape, and running the program. The third of these items involved repeated passes of the tape, and this, on a computer not originally intended for this type of data processing, determined the time taken, which would have been considerably less if the store capacity had permitted the votes themselves to be stored.

The principles and method of PRSTV may best be understood by following what can happen to "your" vote. This is much easier to understand than any explanation of how the Returning Officer must do his work. To you, as a voter, the distinctive feature of the system is that you mark your candidate's name with a "1" instead of a cross, and are free (indeed, encouraged) to indicate second, third . . . preferences by marking 2, 3, . . . against other names.

First your vote is counted with the rest as though the 1 were a cross. The resulting number of votes for your candidate is compared with the minimum number of votes which would guarantee him election. This number is called the quota and is given by the formula,

$$\text{Quota} = \frac{\text{Total votes} + 1}{\text{Vacancies}} + 1$$

What happens next depends on this comparison.

(1) If your candidate has received exactly the quota, then he needs every bit of your vote. *He gets it and all your later preferences are ignored.*

(2) If your candidate is well in the running but has less than the quota, then again, he needs every bit of your vote; *he gets it, and all your later preferences are ignored.*

(3) But if he gets more than the quota, say he gets 150 votes when the quota is 100, *then he gets the fraction of your vote which he needs* (two-thirds in this example) and *the rest of your vote goes to the next* (*needy*) *candidate* on your list.

(4) If this procedure does not yet produce a convincing result, then the man who is now [i.e. after any share-out under (3)] at the bottom of the poll is declared hopeless. If this happens to the candidate to whom you gave first preference, then *your whole vote goes to the next* (*needy*) *candidate on your list*, in the first instance, although if this gives him more than a quota, only the necessary fraction goes to him and the rest of the vote goes to the next (needy) candidate on your list after that, just as in (2) or (3).

Procedure (4) is repeated as often as is necessary to obtain a result in which only the required number of candidates are left in. The meaning of "(needy)" above is simply this, that if, when the time comes to divide or transfer your vote, the next man (or men) on your list is (are) already firmly in or firmly out, then he is (they are) passed over in processes (3) and (4), until a name is reached which can make good use of it.

In practice, your vote is rarely divided into more than two parts. It may go to the first man on your list who can make good use of it or it may go partly to him and partly to the next such man. If your preference is the exact reverse order to that of the majority, it may be transferred several times, as your candidates are each in turn declared hopeless!

The detailed regulations followed by the Returning Officer look rather different from the above description for reasons obviously connected with making his work easier. Suppose that you gave first preference to candidate A and second

preference to candidate B, and that on the first count A is elected with 50% more votes than he needs. Then two-thirds of your vote goes to candidate A and one-third to candidate B. The Returning Officer takes your paper with all similar ones, and puts two-thirds of them back on to A's pile and transfers one-third of them to B's pile. Your particular paper might go either way, but obviously A and B are merely concerned with how many votes they get, not with which ones.

However, this introduces a weakness which, in the writer's opinion, seriously undermines confidence in the practice, though not in the principle of the system. For if B's total now exceeds the quota, the votes he got from A are again divided by next preferences. And now it obviously does matter which of A's votes went on to B's pile, because when the first division was made no care was taken to ensure any averaging out of later preferences, and it could happen that that first division was seriously biased. It would be extremely difficult for any teller to arrange this deliberately without it being obvious that he was "up to something," but "the law of averages" is not, in the writer's opinion, adequate to prevent it happening of itself.

With modern data-handling methods this weakness can be eliminated. It obviously helps the Returning Officer if he always deals in whole votes, and if as the count goes on an increasing number of papers are already in their final positions. To a computer, adding fractional votes is no more trouble than adding whole ones, and it is easier to scan the whole sequence of votes on each count than it is to sort them into piles which have to be differently treated. Accordingly it is to be hoped that if modern data-handling methods are introduced, no attempt will be made to tie PRSTV to those details which were laid down over forty years ago to make the actual organisation of the count tolerable but which in a modern context serve no useful purpose and, in fact, undermine its essential fairness.

For the system has a tremendous amount in its favour. Voters often feel that a vote for a hopeless candidate, or a vote which merely swells a vast majority, are wasted votes. This feeling should be entirely removed by PRSTV. It is also often felt to be wrong that a party which gets 55% of the votes can get 85% of the representation. This is more debatable since a 55% representation makes for an unstable, unsatisfactory government. PRSTV gives exactly the same result as the normal method in single member constituencies and provides strictly proportional representation only if the whole country is one large constituency. Clearly with two, three, or four-membered constituencies, a suitable compromise should be achievable. But this argument only applies where a party system is in operation. For elections such as the social club election, a more interesting light is shed on the working of the system by asking what happens to a man who is everybody's second choice. You may think such a man ought certainly to get in. Under the system described here, if the first preferences are evenly divided, he will be the first candidate to be eliminated, but if there is even one candidate who gets well above the quota on the first count, then he has quite a chance of climbing steadily up the poll to secure ultimate election.

In drawing up the ALGOL procedure, a study of the requirements showed that an elected candidate receives complete all blocks of votes offered to him up to the one which elects him; he receives a fraction of this block and none thereafter. Each candidate is therefore given a status, initially "hopeful" and changing later to "elected in Round No. n" or "defeated in Round No. n." An elected candidate is also given a "need figure"—the proportion of the last block of votes which he accepts. A "Round" consists of a complete scrutiny of all votes. As each vote is scrutinised, the procedure must consider the status of the expressed preferences in order and allot fractions of the vote until it is all allotted. At the end of the Round, totals for each candidate are announced and the status of at least one candidate is altered. If the allotment is correctly done, candidates elected on previous Rounds will be found to have a quota; any candidates with more than a quota are declared elected and a "need" is worked out for the one with most votes, but if there is none, then the candidate with least votes is declared defeated.

The allotment rules are simple. A "hopeful" candidate gets all that is left of the vote. A defeated candidate gets none, but a note is made of the Round in which he was defeated, since prior to that round he will have been "hopeful." An elected candidate also gets none if he was elected before the vote became available, i.e. while the voter's previous choice was still "hopeful." But if he was elected as a result of the previous preference being defeated, his need figure is consulted, while if he was elected later, then he receives all that is still unallotted.

It might have been simpler either (*a*) to give every candidate a "need" as soon as he is elected or (*b*) to elect no more than one candidate per round, but the above procedure follows more closely the existing regulations, modifying them only in the one respect already declared to be unsatisfactory, by taking advantage of the ability of the computer to scrutinise all votes on each round and to handle fractions of votes. The full procedure given below is incomplete in another respect, however, namely in not including the correct procedure for the unlikely event of an actual tie for top or bottom place. On a machine with limited storage it was considered better to override the program manually in this case, since the decision is based on previous counts which the present program prints out but not does store.

An amusing example of the discipline of ALGOL, or rather of the results of evading it, occurred when the program was run. During the machine coding of the program, by hand, provision was made to type the totals of "hopeful" candidates in black, but of elected or defeated candidates in red. This should have been accompanied by a modification of the ALGOL procedure, changing type (x) into type (x, s), and had this been done less surprise would have been occasioned by the fact that the first round of typing (which should be all zeros) consisted of a black zero for each candidate followed by a red zero for the non-transferable vote.

The complete procedure was as follows:

procedure Proportional Representation Count (m) number of candidates and number of vacancies: (v); *integer* m, v; *begin*

integer s, vote count, preference, q, test, t, u, Round, Candidates over Quota;

real non-transferable vote, vote value, allotment, Quota, maxvote, minvote;

array new votes, old votes, need [1 : m];

integer *array* name, status [1 : m];

procedure Read paper (L), type (x);

begin Round: = 0; non-transferable vote: = 0;

for s: = 1 *step* 1 *until* m *do begin* status [s]: = new-votes [s]: = 0; need [s]: = 1 *end*;

```
M: for s: = 1 step 1 until m do begin old votes [s]: = new
      votes [s]; newvotes [s]: = 0; type (old votes [s]) end;
   type (non-transferable vote) non-transferable vote: = 0;
      vote count: = 0;
P: Read paper (S); comment this calls the input and stores
      the contents of one voting paper as an array called
      "name" whose nth term is the serial number of the
      nth preference (or zero if there is no nth preference).
      If there are no more papers it goes to S;
   vote count: = vote count + 1; preference: = q: = 0;
   vote value: = 1;
R: preference: = preference + 1;
   if name [preference] = 0 then begin non-transferable
      vote: = non-transferable vote + vote value; go to P
      end;
   if status [name [preference]] = 0 then test: = 1
      else test: = abs (status [name [preference]]) − abs
         (q) − 1;
   if test ≥ 0 then q: = status [name [preference]]; comment
      on each round the computer recapitulates the counting
      done on previous rounds in so far as this represents
      the final allocation of a vote. If a vote has been
      transferred several times then q is an indication of how
      long the current holder managed to keep it and if
      test < 0 then the present preference was out of the
      running (either elected or defeated) before the current
      holder released it;
   if status [name [preference]] < 0 ∨ test < 0 then go
      to R; if test = 0 then allotment: = need [name
      [preference]] × vote value
   else allotment: = vote value;
      new votes [name [preference]]: = new votes [name
         [preference]] + allotment;
      vote value: = vote value − allotment;
   if vote value = 0 then go to P else go to R;
S: if Round = 0 then begin Quota: = vote count/(v + 1)
      + 1; Candidates over Quota: = 0 end;
   Round: = Round + 1; t: = u: = maxvote: = 0; min-
      vote: = vote count;
     for s: = 1 step 1 until m do begin
        if new votes [s] < minvote then if status [s] ≥ 0
           then begin minvote: = new votes [s]; t: = s end;
        if new votes [s] > maxvote then begin maxvote: =
           new votes [s]; u: = s end;
        if status (s) = 0 then if new votes (s) > Quota then
           begin status [s]: = Round; Candidates over
           Quota: = Candidates over Quota + 1 end end;
   if Candidates over Quota > 0 then begin Candidates
      over Quota: = Candidates over Quota − 1; need
      [u]: = (Quota − old votes [u])/(new votes [u] − old
      votes [u]) end
   else status [t]: = − Round;
   go to M end end
```

COMPUTER COURSES 1961

The Editor has received details of courses in Educational Institutes additional to those published in the previous issues. Details of other 1961 courses will be published in the next issue of the *Bulletin* if the information reaches the Editor by 15 April 1961

Courses

Courses	*At*	*Commencing*	*Fee* £ s. d.	*Lectures*	*Times*
Character Recognition, Data Transmission, Document Handling	Northampton C.A.T., London	27 March	5 5 0 (3 3 0 for Members)	Full-time (27–29 March)	
Pegasus Autocode	Southampton University	27 March	5 5 0	Full-time (27–29 March)	
ALGOL 60	Brighton College	5 April		Full-time (5–6 April)	

Computer Manufacturers

It has not proved possible to summarise the variety of courses offered. Much helpful literature is available and it is suggested that interested readers write to:

AEI Ltd.	K. C. Evans, Electronics Apparatus Division, Trafford Park, Manchester 17.
Bulmers (Calculators) Ltd.	A. R. Rider, 47–51 Worship Street, London, E.C.2.
Elliott Bros. (London) Ltd.	F. S. Ellis, Elstree Way, Borehamwood, Herts.
EMI Electronics Ltd.	J. W. Godfrey, Computer Division, Hayes, Middlesex.
English Electric Co. Ltd.	J. Boothroyd, Data Processing and Control Systems Division, Kidsgrove, Stoke-on-Trent, Staffs.
Ferranti, Ltd.	R. Wilkinson, 21 Portland Place, London, W.1.
IBM United Kingdom Ltd.	The Education Department, 101 Wigmore Street, London, W.1.
ICT Ltd.	F. A. Worsfold, Bradenham Manor, nr. High Wycombe, Bucks.
Leo Computers Ltd.	R. P. Gibson, Hartree House, 151A–159A Queensway, London, W.2.
National Cash Register Co. Ltd.	D. H. Triggs, 206–216 Marylebone Road, London, N.W.1.
Standard Telephones and Cables Ltd.	F. G. Filby, Information Processing Division, Corporation Road, Newport, Mon.

ADDITIONS TO THE LIBRARY

Any enquiries relating to material appearing in this list should be made to the Honorary Librarian, F. C. Adey, F.L.A., Chief Librarian, Leicester Colleges of Art and Technology, Leicester.

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REGIONAL BRANCH NEWS

BIRMINGHAM

The first two meetings of the 1960–61 session were concerned with American progress in Data Processing and some experiences with magnetic tape equipment.

On 19 October Mr. J. G. Grover gave a talk on his recent visit to the USA as a member of an OEEC Mission on Data Processing. The mission consisted of 25 experts from 11 European countries who visited as many of the large computer installations and factories as possible, to obtain a broad picture of recent American experience in the field of large scale Data Processing.

Mr. Grover described the main technical trend as a move in the direction of miniaturisation, and the use of solid state devices. Such was the increase in reliability that preventative maintenance could be scheduled for week-ends only. Other trends observed were the use of plug-in peripheral units, designs intended for rapid extension, and higher operating speeds.

In the peripheral equipment line printers operating at 600 lines/minute were fairly common and devices operating at 5,000 lines/minute were available, and input units using magnetic ink reading were coming into use.

The increasing use of computers has stimulated the development of accurate data transmission links working at speeds of 1,000 bits/sec. on audio circuits, and up to 100,000 bits/sec. on microwave radio links.

In general the major financial savings were shown by large users, such as banks, insurance companies, and public utilities, who started from punched card systems, rather than by smaller concerns. Fully integrated Data Processing appeared to be a future aim, rather than a present fact, being most nearly realised in particular applications such as warehouse and stores operation.

The widespread use of automatic coding was observed; this was estimated to reduce training and programme writing time by a factor of about 15. The US Government, as the largest user, was pressing strongly for the use of COBOL as a common language for semi-automatic coding for all computers engaged on commercial work.

In the educational field, all courses on business administration appeared to include work on computer programming.

Mr. Grover concluded with a tribute to his American hosts for their hospitality and unstinted co-operation during the mission's visit.

On 9 November Mr. G. B. Griffiths described his company's experiences with magnetic tape equipment. *Messrs. Babcock and Wilcox* are manufacturers of large boilers, and use their Pegasus computer for design work as well as commercial data processing. In the former category, stress calculations on large structures, involving the solution of large matrices, have been solved in a third of the time previously required, by using magnetic tape as a backing store, rather than punching out intermediate data on paper tape, and subsequently re-reading.

A typical commercial data processing application which required the magnetic tape equipment was the control of engineering stock, and considerable programming effort was devoted to general routines for tape reading, tape writing, merging, up-dating of files, etc.

Of the four tape units available, one carries all normally used programs, and a second carries experimental programs, each having some space on the reel for program testing.

The tape units used pre-addressed tape, with a parity check bit in each word, a check sum in each block of 32 words, and reading heads for checking the data as it is written, and had proved reliable in service. In the rare event of a failure of the check sum during reading, a programme was written to read all the words in the block in octal notation, and print them out. This generally enabled the error to be found by inspection.

Mr. Griffiths concluded with a description of the methods used for handling and storing the tape, and checking its condition by means of a test program.

GLASGOW

Attendances at last year's meetings were very disappointing. The topics discussed then were based for the most part on large computers. Feeling that perhaps meetings were dealing with machines at the wrong end of the scale, the Committee devoted the first half of the 1960–61 session to the Electronic Calculator. Attendances have doubled. This, however, may be due to the fact that the speakers were local and, no doubt, brought their Supporters Clubs along with them!

At the first meeting held on 17 October the Branch Chairman, Mr. K. D. Henderson of *J. & P. Coats*, spoke of the planning and development stage which precedes the installation of a computer. Mr. Henderson felt very strongly that the normal commercial or industrial concern should gain experience with a punched card installation first and develop with the use of an electronic calculator. This was the pattern followed by *Coats* who were in the process of installing an ICT 555. Events had made Mr. Henderson more convinced than ever that the course taken was the best one. During the punched card and electronic calculator stage, clerical routines are streamlined and data put into a form suitable for easy absorption by a machine system so that many of the input problems have been dealt with before the introduction of a computer. Also a team of the correct calibre, members of which can graduate on to the computer, is built up, and the members of the other sections of the concern grow accustomed to working with coded tabulations.

The difficult task of dealing with the hardware itself was handled in a first-class fashion by Mr. W. A. Donaldson of *Rolls Royce, Hillington, Glasgow*, at the Branch meeting held on 14 November. Mr. Donaldson had under his control an ICT 555 and an IBM 628 and was able to compare the machines in a most practical way. After dealing with the specifications of the two machines, he went on to mention the features of each which he had found to be helpful and those which he had found to be limiting. The two applications which he described were in the field of material control and illustrated the types of jobs to which each of the machines was particularly suited. Mr. Donaldson felt that the ICT 555 and IBM 628 marked the top of the Calculator range and that the specification of future machines would be less comprehensive and expensive. The work presently undertaken by these

machines would be taken over by small computers; something like a slightly scaled-down ICT 1301 or IBM 1401.

The final meeting of the series held on 12 December was an ambitious one, in that an attempt was made to cover the experiences of four users of Calculators in one meeting. The four speakers were:

Mr. T. B. Simpson, *John Brown & Co. (Clydebank) Ltd.*
Mr. Eric Maxwell, *South of Scotland Electricity Board.*
Mr. J. C. Mair, *Western Regional Hospital Board.*
Mr. G. B. Esslemont, City Chamberlain, *Glasgow Corporation.*

The machines used by these concerns included an IBM 628, an ICT 555 and a PCC, so that a very comprehensive picture of the field covered by Calculators was given. Although a substantial part of the evening was taken up by the original addresses, ample time was left at the end to discuss such subjects as the rounding up of nett pays to an even number of shillings and the security arrangements required when staff salaries are handled on the calculator. Members and guests numbered about sixty for this meeting and the good attendance augurs well for the new year.

LEICESTER

On 17 November, 1960, at the Leicester College of Technology and Commerce. Members were addressed by Lt.-Col. J. J. Wise and Mr. Thurston.

Central Ordnance Depot, Chilwell, has a stock inventory size of 200,000 mechanical transport spare parts, which it supplies to the Army at home and abroad.

In 1956 an Inter-departmental Committee was set up to examine the feasibility of employing electronic computers for stores work in the Army. The Committee recommended the introduction of ADP and suggested that it be first introduced into the R.A.O.C., being the largest stores organisation in the Army, and in C.O.D. Chilwell initially.

A specification was drawn up and staff were trained to evaluate manufacturers' tenders. An order was placed for an EMIDEC 2400, which will be delivered in 1961 and be available for processing on 1 January 1962.

Computer Programming Teams were formed of both military and civilian officers. An Automatic Data Processing Unit was formed as a task force for the introduction of the Computer. This Unit is under the technical control of Colonel ADP in the War Office.

Programs have been based on a thorough O & M study of present working methods and opportunity was also taken to visit various large commercial organisations with a comparable inventory and control problem. The initial application, which will cover mainly the accounting and purchasing functions, was then written up in the form of narratives, each of which gave a description of how individual processes would be carried out in the ADP age. Each was thoroughly discussed with management.

These 14 narratives were then welded together as a complete integrated data process. This again was discussed with management and programming then began in earnest.

The daily cycle comprises three main processes, compilation, editing and posting. In the compilation process, data is taken from a tape prepared by the card to tape converter, compiled into transactions, tested for feasibility and output on tape in blocks of up to 350 words. After sorting into file sequence, this tape is run against a catalogue file to carry out, on the data tape, any editorial amendments and to reject data which is unacceptable. The majority of editorial amendments will result from changes in part numbers on basic files and the part number keys on the data tape will be amended or left unaltered depending upon the stock status of the part number demanded and the basis upon which it has been superseded by another part number.

Following the editorial process there will be a sort of those transactions whose part number key has been changed. Then will come the main daily process using the stock file and comprising amendments, the posting of issues, receipts and stocktaking adjustments, the production of issue vouchers and control data, the generation of main depot stock replenishment demands on sub depots and various loop back transactions to be dealt with the following day. It is anticipated that the total number of instructions in this process will be about 17,000 or more and therefore a 20,000 word core stock has been ordered.

There are a number of weekly processes, one of which concerns procurement. Some 4,000 items will be reviewed each week on a cycle and, in addition, it is anticipated an additional 500–1,000 items will require reviewing each week on an *ad hoc* basis. Normal provision is based on past usage projected forward but this is subject to modification by the Purchasing Officer, who can insert or alter a modifying factor prior to the date on which an item is due to be reviewed. All of these reviews will result in a print out for the Purchasing Officer's attention. All other items, however, will be reviewed once a month in order to calculate the up-to-date danger levels of assets and stock at which *ad hoc* reviews must be carried out.

The total number of instructions will be approximately 50,000 and the aim is simplicity with the avoidance of sophisticated programming tricks in this first stage. This is for two reasons, namely ease of program testing and ease of handing over to second generation programmers.

The conversion task is large, involving the initial punching and verifying of some 360 million characters and before this can be carried out these characters must be validated.

The first programs are now approaching the testing stage and in fact one program, covering the posting of receipts, had been proved.

MANCHESTER

At a meeting held on Thursday, 10 November 1960, in the Manchester College of Science and Technology, Mr. J. W. Judd of the O. & M. Department of the General Post Office, spoke to members and their guests on "Premium Savings Bonds—A Large File Computer Application."

Mr. Judd started by saying that he first came into the computer field in 1956 at about the time of the introduction of Premium Savings Bonds. At that time the Bonds system had to be operating sooner than the earliest possible delivery date for a computer and so a manual system had to be introduced. The speaker explained this system (which had taken about 12 months fully to investigate) in detail and gave some idea of the size of the problem by reference to the size of the present staff, the 35 million records, the rates of purchase and repayments and the difficulties that sometimes arise in trying to comply with the customers' wishes.

Next Mr. Judd considered the various conditions that would have to be complied with by the computer system and the possible solutions; the speaker explained all the points for and against the various ideas and all the ramifications in

a most lucid manner so that even those members who came with fixed, but wrong, ideas of the Premium Savings Bond problem were able to obtain a balanced view-point. Among the many little tit-bits of information it was interesting to learn that there were already a quarter of a million Smiths holding bonds of which 6,600 had the initial J and 50 of these lived in Leicester; this really brought home to the audience the problems related to identifying the correct record.

The speaker concluded his talk, which lasted nearly an hour, by giving his audience an idea of the research work that was going on in the solution of the problems that could not be solved with equipment currently available such as the comparison of one signature with another.

Mr. Judd kindly consented to answer questions put to him by the audience and such was the interest aroused in his talk that they did not cease until the Chairman, Dr. C. B. Haselgrove, stemmed the flow after forty minutes because of the shortage of time.

BOOK REVIEWS

Information and Decision Processes

Edited by R. E. Machol, 1960; 185 pages. (London: *McGraw-Hill Publishing Co. Ltd.*, 46s. 0d.)

Those readers who, like myself, actually read the preface and introduction to a book before reading the book itself, will be in a high state of excitement at the thought of the treats to come as they read that this book gives written accounts of the views of ten of America's leading scholars on problems of information and decision processes. In an admirable survey of the developments over the last twenty years, it is pointed out that in the first decade the seeds were sown for a major intellectual revolution with the design, construction and successful operation of the first stored-program digital computer, the development of the mathematical theories of information and decisions, and the rapid application of mathematics in the new fields of decision-taking, programming and statistics. Although the second decade did not produce so many revolutionary new ideas, it was a period of tremendous advance and consolidation and an opening of mental horizons. The prejudice against the possibility of thinking machines was largely shed. We are led to believe that the twelve papers that follow shed important light on these wide issues.

Let me prepare the reader for a disappointment.

The first paper considers the problems of computation in decision-making and spends the first half-dozen pages explaining how the simplest combinatorial problem could lead to an enormous number of cases to consider. Some scathing, but justified, remarks are made about the uncritical use of game theory, and come to the conclusion that if we are going to make any advance in problems which with our present understanding require enormous calculation, then we must have a bright idea if we are to "expect truly marvellous consequences."

If the reader is not somewhat dampened at this point, he may read the paper on the sequential design of experiments. This is an expository article by Chernoff on his justifiably well-known work in this field, but it does not widen our horizons much.

J. L. Doob contributes a paper on problems in the consistency of mathematical models, which is a very clear account of the difficulties in formalising a real situation into mathematics, but I should be sorry to hear that it actually deepened anybody's understanding.

M. M. Flood gives a good expository account of sequential decisioning, and this paper makes a good reminder of the work that has been done.

This is followed by a technical paper by Hoeffding on "The lower bounds for the expected sample size of a sequential test," which must have intrigued the philosophers present at the conference at which it was delivered.

David Rosenblatt in his paper "On some aspects of models of complex behavioral systems" treated the formal and pragmatic aspects of such models through graph theory. This is pretty but condensed mathematics, whose relation to real modern-day problems never became apparent to the reviewer. It did, however, have some interesting historic references, showing the ideas of this modern subject to have been anticipated by Pacioli in 1494, Isnard in 1781 and Gibbs in 1886.

A short paper by M. Rosenblatt on the conditions for an aggregation of a Markov chain to be a Markov chain occupies a further three pages.

Shannon contributes a long paper on coding theorems for discrete sources with a fidelity criterion, and this displays Shannon's usual ingenuity of mathematical exposition.

Milton Sobel contributes a paper on a special sequential decision process which is a delight to read.

In "Statistical Decision Theory in Engineering" by L. Weiss there are some critical remarks about classical decision theory and he advocates the use of Bayes's theorem.

Wolfowitz contributes a highly compressed technical paper in communication theory, and, finally, Patrick Suppes gives a delightful account of the difficulties of subjective probability as advocated by Savage.

This is an interesting book—rather uneven in the quality of its papers—but everyone will find something of interest. They will not find it widening their horizons.

K. D. Tocher

Annual Review in Automatic Programming

Edited by R. H. Goodman, 1960; 300 pages. (Oxford: *Pergamon Press Ltd.*, 63s. 0d.)

This is rather a disappointing book. It contains the papers presented at a Conference on Automatic Programming held at Brighton in April 1959. Most of the papers fall into one of two groups, generalisations about the state of the art which, though eminently suitable for conference consumption, lose their value rapidly afterwards, and descriptions of various simplified programming schemes available for English computers. As it is now nearly two years since these papers were delivered and considerably longer since the programs described in them were written, it is hardly to be expected that the ideas involved will be the very latest in this

rapidly developing field. The general picture which emerges is incoherent and confused and I do not think that this is entirely the result of printing a number of independent conference papers. It springs principally from the primitive state of development of automatic programming methods in this country which in its turn is largely a consequence of the unsuitable nature of English computers.

Modern concepts of Automatic Programming view the problem of communication between the user and the computer as a whole, and bring the various stages between the design of the program and the final execution into a single coherent system. There is very little sign that this concept has made any headway yet in this country and most of the programming systems described in this book are really aimed at getting round the inherent complications of the machine for which they are designed. The paper on the "Share Operating System for the IBM 709," although it only gives an outline of the system, shows clearly how far ahead of us in this field the Americans are by now.

The last sixty pages of the book should be ignored. They contain an entirely irrelevant reprint of Turing's original paper on Computable Numbers together with a subsequent correction to it and a copy of the preliminary report on ALGOL which is now both obsolete and misleading.

C. STRACHEY

Computer Engineering

Edited by S. A. Lebedev, 1960; 184 pages. (Oxford: *Pergamon Press Ltd.*, 63s. 0d.)

This book contains eight papers on some aspects of computer engineering in USSR translated into English. The references quoted by these papers are not later than 1956 which makes the book something of a "period piece." In view of the rapid strides in computer technology since that date both inside USSR and elsewhere, the interest of the book is historical rather than technical.

The first paper deals with power supplies for the original BESM machine and deals with regulation and also marginal checking by variation of filament supplies. There follows a long paper of 74 pages on Digital Differential Analysers which is almost entirely a review article of US practice. No less than 21 out of 22 references are to US publications.

Next appears a very good account of "Dynamic Flip-Flops and their Use in Parallel Action Computers." This extends over 38 pages and is quite stimulating. Interesting applications are shown for frequencies up to 1 Mc/S. Naturally this is entirely based on thermionic valves and not transistors.

The remaining papers are shorter and deal with a form of parity checking in a serial arithmetic unit; dictionary look-up for mechanical translation, properties of ferrite cores for coincident current and word selection stores; and a glossary of technical terms. There is nothing novel in these papers and comparable information is readily available in the usual scientific and technical journals.

There are a few small misprints, particularly among the references, but these will not mislead any historians of computers.

P. TAYLOR

Proceedings of the 1959 Computer Applications Symposium

1960; 155 pages. (Illinois: *Armour Research Foundation of Illinois Institute of Technology*, $3.00.)

As in previous years, these proceedings are divided into two sections. One section contains seven papers on Business and Management Applications, and the other has an equal number on Engineering and Scientific Applications. There is, however, an obvious theme common to both sections, namely that of automatic programming languages. A paper by Albertson describes the work of the Committee on Data-Systems Languages. The properties required of such a language are given, from a businessman's point of view, and it is perhaps not surprising that these properties are very similar to those needed in a language designed for scientists. Ross's paper describes the APT language for automatic programming of numerically controlled machine tools. Katz gives the history of ALGOL up to mid-1959, so no mention is made of the various papers which have since appeared on ALGOL 60. Contributions by Atchison and Engel are also concerned with automatic programming techniques. The former advocates their use because it is then easy to change from one computer to another without too much reprogramming; the latter reviews the merits and demerits of FORTRAN with particular reference to the utilisation of off-site computers.

Another paper in the Business section is by Wells, who describes means of producing output from a computer in a form which can be transferred to cards, envelopes, etc. Four papers by Hanna, Hamaker, Wilson and Harvey treat different aspects of methods for stock and inventory control. Alexander reported on a visit made by a number of Americans to the USSR for the purpose of seeing various Soviet computers. Transistorised computers were not seen, but the author emphasises that this does not rule out their existence. In the USSR, computers were not used very much for Business applications.

Papers, not already mentioned, in the Scientific section are by Wall, who explained how linear programming could be done quite satisfactorily on a comparatively small computer; and Glaser and Harris who explained the role which computers are playing in the design of small electronic packages and of lens systems, respectively.

At the end of each day's session, there was a Panel Discussion which appears to have been reported verbatim. Such a presentation has both advantages and disadvantages. An advantage is that the reader gets the "atmosphere" and the impression that he was there—obviously some of the discussions were very heated. A disadvantage is that too much irrelevant material is included and the whole thing has to be read as a play. The following extract is typical:

> "H. R. J. Grosch: 'Look, I have to catch a 5.45 'plane. I do not want anyone to think I am running away.' (Dr. Grosch and Mr. Ross left at this point. Dr. Grosch, unhappily, missed his flight.)"

Having said this, one should hasten to add that the second discussion does, nevertheless, make interesting reading; it is primarily concerned with the pros and cons of FORTRAN, ALGOL and other automatic programming languages.

G. N. LANCE

Digital Computer Fundamentals

By T. C. Bartee, 1960; 342 pages. (London: *McGraw-Hill Publishing Company Ltd.*, 50s. 6d.)

This is a well written and handsome book for the beginner interested in the detail of computers and not merely the principles. An ability to read simple circuit diagrams is assumed and many computer elements such as flip-flops and adders are given from typical USA machines.

There is a very simple chapter on programming followed by fuller ones on number systems, basic logical circuits (mostly transistor circuits), logical design (i.e. Boolean algebra). Then the main machine units—arithmetic, storage, input-output, and control each receive thorough and adequate treatment for an introductory book.

Exercises are set at the end of each chapter. Unfortunately a number of errors in the text will hold up the student who is not experienced. In particular there are many errors in Figs. 6–15. Several references are given for each chapter, but not all are generally available, e.g. Lincoln Laboratory Technical Reports, and so not so useful. All in all this is a book well worth having by the circuit engineer who wants to understand computers.

P. TAYLOR

Computer Abstracts

Edited monthly by B. A. Fancourt. (London: *Technical Information Co. Ltd.*, £25 4s. 0d. per annum.)

Those of our readers who have not yet seen this periodical will, no doubt, be impressed when they get an opportunity to do so. It contains a remarkably comprehensive collection of up-to-date abstracts. These are briefer than those which are now becoming available in "Computing Reviews," but are competently prepared and obviously edited with care; "analog" and "program" in American articles have even been translated to "analogue" and "programme." They are now printed in letterpress, but still only on one side of the page so that librarians may cut them out for card indexes. Logical design and all classes of computer application are well covered, and also the worthwhile papers on components and circuitry.

S. GILL

First Conference on Automatic Computing and Data Processing in Australia

(Summarised Proceedings)

1960; about 300 pages. (Sydney: *Institution of Engineers*, £2A.)

"Proceedings" is something of a misnomer for this volume, which is merely a collection of summaries of papers presented at the Conference and contains no record of the discussions that took place. Apart from this, however, it is probably the best solution to the eternal problem of crystallising Conference material for future reference. It has appeared remarkably quickly following the Conference and contains enough detail about each paper for the reader to understand its primary purpose.

This was a remarkably well-packed Conference. About 150 papers drawn from a very wide field were packed into four days. A glance through the summaries will dispel any illusions which anyone may have about computers being of concern to one group of people only. There are several papers concerned with guided weapons, as one would expect from Australia, but there is also expressed interest in the full range of business data processing and a very lively awareness of new developments in logical design and programming.

S. GILL

Report on Conference on User Experience of Electronics in Industry (May 1960)

1960; 80 pages. (London: *Electronic Forum for Industry*, 21s. 0d.)

With the holding of the Instrument, Electronics and Automation Exhibition at Olympia in May 1960 the EFFI felt that opportunity arose to hold a conference under the title "User Experience of Electronics in Industry." The conference ran for three days, dealing with "Electronics in Data Processing," "Electronics in Factory Applications" and "Electronics in Instrumentation and Control." A report of this conference is now published.

The report is a transcript of recordings made during the conference. For people who attended the conference it is a complete account of all the formal speakers, including the opening remarks of the Chairman at the various sessions. It leaves out, however, the comments of speakers from the floor and any questions which were asked. This is a pity since by including real time remarks such as "Good afternoon, ladies and gentlemen," the reader is given atmosphere yet he misses what is often the most interesting part of the proceedings—speeches from the floor and questions.

For those who did not attend the conference the usefulness of the report will depend on how far advanced they are in the use of electronics.

The first session dealt with Data Processing. It covered applications of computers in Maintenance Stores Control, Production Control, Insurance and Stock Control.

The uninitiated will find this useful but the experienced will find little new in the papers.

Session two dealt with electronics in factory applications. Papers covered numerical control of machine tools, electronics in the steel industry and induction heating. The papers on numerical control give interesting statistics of the economics and reliability of current systems. Again, however, the papers will appeal more to the newcomer in the field than the experienced. The final session contained papers on electronics in instrumentation and control. Included in this were the use of electronics in handling and proportioning, continuous control of machines and remote control and delivery. As in the other sessions the papers are about $3\frac{1}{2}$ foolscap pages long and only general points are made. Nevertheless, the authors manage to make them interesting and describe both their successes and their trouble areas.

To summarise, the report gives

(1) those who attended a record of the papers, but not questions and comments from the floor.

(2) those who did not attend and who are newcomers to any of the fields covered, useful statistics. The rest will probably agree that their experience is similar to that of the authors.

P. G. BARNES

Fundamentals of Digital Instrumentation

By D. S. Evans, 1960; 39 pages. (London: *Hilger and Watts Ltd.*, 7s. 6d.)

This is a small book (6 in. × 6 in.) equivalent in length to a medium-sized paper in the *Computer Journal*. The information is loosely packed, but clearly presented, and it does achieve one of the author's aims—to provide an introduction to analogue-digital conversion for engineers and designers meeting the problem for the first time. Such an introduction should give references to other and more comprehensive work and the author gives none.

There is a brief introduction to digital data handling and the binary system; this is marred by a mistake in the notes on economy of components for large numbers. Then there is a short discussion on the use of binary-coded decimal, cyclic and reflected codes with particular reference to shaft digitisers. Finally, the author deals briefly with decoding and printing information, and introduces the idea of time-sharing of equipment with some practical examples.

D. V. Blake

Linguistic and Engineering Studies in the Automatic Translation of Scientific Russian into English (Phase II)

Edited by Erwin Reifler, 1960; 492 pages. (Seattle: *University of Washington Press*, $10.00.)

Erwin Reifler, the editor of this report, is one of the pioneer workers in the field of M.T. By profession a Sinologist, he is also expert in the Slavonic languages, and it is natural that his department at Seattle should be a major recipient of Government sponsorship in the USA. This handsome volume is the second which has been produced by the group and its size and content provide a measure of the calibre of the group and its work.

To make the volume reasonably self-contained Reifler provides a brief historical outline, a statement of the fundamental problems as he sees them, and an up-to-date bibliography. This is followed by two papers by L. R. Mickelson dealing respectively with lexicography and with M.T. operational analysis. The first of these papers will be of the greatest use to other workers in the field, since it contains linguistic-statistical data derived from a 31,403-word Russian text sample. The second paper contains a valuable analysis of Russian from the M.T. viewpoint, but, whilst it greatly appealed to the reviewer, it may enrage those who despise the heuristic approach.

These two chapters are followed by no fewer than 163 pages of simulated machine translations. The quality of some of the latter leaves much to be desired, but, on the whole, they will serve as a useful mine of information regarding the sort of problems which will be encountered in practice.

These topics, which form part one of the report, occupy nearly three-quarters of the book. The second part, engineering analysis, starts with an account of the role of the digital computer in M.T., by D. L. Johnson. This deals with computer practice and follows familiar and well-trodden ground, but it is followed by a paper by R. E. Wall which contains a good analysis of the data processing problem based upon the statistical evidence which is accumulated in the first part of the book. It contains also a description of some proposed methods of measuring translation quality, a detailed description of the steps which the data processing operation involves, a discussion of experiments carried out on an IBM 650 machine, and finally a discussion of the structure which is envisaged for an *ad hoc* translating machine. There are several appendices to this paper the most interesting of which deal respectively with the optimum arrangement of entries in a dictionary and with the economics of M.T. It was particularly interesting to the reviewer that this independent assessment of costs reached substantially the same conclusion that he voiced at the Cleveland conference in 1959. This is that the major item of expense is text preparation by typists, the elimination of whom, by electronic readers, is almost essential to the commercial success of M.T.

This major paper is followed by a shorter, but interesting, account of the block analysis of Greek sentences by means of a computer. A useful feature of this section is that its author, A. D. Strathacopoulos, presents a complete programme of machine instructions suitable for an IBM 650 machine.

The book ends with a reprinted paper on pattern recognition in an electronic reader by P. M. Pahl and D. L. Johnson, and an account of logical programming research at Seattle by L. R. Mickelson and R. E. Wall.

It would be quite impossible to make detailed comments on this impressive volume in any reasonable space. It is well written and produced and forms, with its earlier companion, a most valuable addition to the literature of M.T. which will be an essential reference for all working in the field.

A. D. Booth

Soviet Technology Digest

Edited by M. M. Barash, December 1960; 149 pages. (Oxford: *Pergamon Press Ltd.*, £10 per ann.; New York: *Pergamon Press Ltd.*, $30.00 per ann.)

This is the first issue to be published by Pergamon Press of a monthly periodical which is intended to provide express information on recent technological developments in the Soviet Union and Eastern Europe. It contains a few hundred two-line abstracts of articles in technical journals and a few thousand-word summaries accompanied by diagrams. Unfortunately this book is not, itself, arranged for easy reference. There is a strong bias to production engineering, but several other subjects such as nuclear physics are also involved. The reviewer could find only one reference of particular interest to computer users (concerned with error accumulation) although there are several more of interest to computer engineers.

This is one of several praiseworthy attempts that are now being made to provide the Western world with information about Russian technical progress. We must look forward to the day when Russian computer work in particular is made regularly available.

S. Gill

Planning for Productivity in the Oil Industry

Edited by G. Sell, 1960; 161 pages. (London: *The Institute of Petroleum*, 35s. 0d.)

This little book is a report of the Summer Meeting of The Institute of Petroleum which was held in Bournemouth on the 25–28 May 1960. The object of the meeting seems to have been chiefly to introduce new techniques to management. For this reason the technical level is elementary (elementary to the point where the sign $\geqslant$ is explained). The level of presentation, given this restriction, is uniformly good and the book gives a readable account of some new developments in the oil industry.

It is difficult to see, however, what class of readers concerned with computing will find benefit from it. Those already in the oil industry will be well acquainted with the techniques. Those not in it might find it useful as an elementary exposition of the problems of that industry.

The field covered includes operational research, dynamic programming, organisation of control laboratories, distribution of products, and the use of analytical on-line instrumentation. The use of computers for on-line control is mentioned only very briefly.

Perhaps the most interesting part of the book is the record of discussion, in which the technical level is in some places much higher than the content of the papers would lead one to expect. One particularly interesting point which comes out in the discussion is made by Gallon. He points out that on a typical refinery product such as gas oil something like twelve routine tests are carried out. Statistical analysis has shown that the twelve properties which are tested are highly correlated and, in fact, there are only about five significant variables. This is a result that could lead to some simplification and clarification of testing procedures.

H. H. Rosenbrock

THE IBM 3000 ACCOUNTING SYSTEM

Mechanical aids to work in the office have been introduced over several decades, but developments in the last few years, in the form of computers and other electronic equipment, have tended to affect the larger organisation only. Yet the paper work of the small business, though less, is sometimes as detailed as that of the larger organisation. (This fact has long been recognised by the British punched-card Powers Company, which has produced 21 column *Powers-one* and 40 column equipment.)

Now, with the introduction of the IBM 3000 accounting system, the benefits of IBM 80 column punched-card accounting have been brought to an entirely new range of organisations. All the accounting and record-keeping operations of a small business can, it is claimed, now be carried out with a speed and accuracy not attainable by manual methods, and by a low-cost accounting system that occupies less office space than three desks. The argument for justification of the new equipment will be even more powerful, for branches of large organisations, if, at a later date, a method of communication from the new card form to a full-scale 80 column system is announced.

The IBM 3000, which has already appeared on the Continent, was shown for the first time in this country on 24 January by *IBM United Kingdom Limited.* It consists of four machines:

(1) A punch/verifier model 3020, on which information is recorded by a typewriter keyboard, with a bank of numeric keys in punched-card form and then verified.

(2) A card sorter model 3080, which can sort cards into alphabetical or numerical sequence at 460 card-passages per minute. This machine is compact and stands on a table top.

(3) An accounting machine, which combines several functions in one machine, including calculating, punching, reproducing and printing. This is known as the model 3000 accounting machine and its basic speed is 90 cards per minute.

(4) The IBM 3050 interpreter, an optional extra in the system, which interprets cards at 45 cards per minute.

The 3000 has been called "revolutionary" for two reasons: the punched card used with the system, though measuring approximately 4·12 in. × 2·61 in., contains the full 80 columns and IBM research has brought about the first machine in which the ability to calculate, print and punch is combined in a single processing unit. Reading of the card visually is facilitated by the punching of even-numbered columns approximately 2·5 mm below the datum point of odd-numbered columns. New punching and reading mechanisms are used.

The sequence of the datum points in the card form is the reverse of the sequence first used in the United Kingdom on LEO I, where the 12 row positions are valued 0, 1, . . ., 8, 9, 10, 11 in order. In this case the 0 row is where we normally find 9 and the more logical sequence will simplify sorting and tabulating mechanisms.

The new system is designed for users for whom conventional 80 column punched-card equipment is not an economic proposition. Typical applications of the IBM 3000 would be invoicing, stock control, payroll, sales analysis, accounts receivable and accounts payable. Ready-programmed applications are available with the machines, based on extensive studies of typical business problems. 10d. and 11d. may be punched in one column. We are advised that the accounting machine control panel will be plugged to add these correctly and print them in two columns. H. W. G.

NEWS FROM MANUFACTURERS

*NCR*315 *Computer Has New Design of Random-Access Memory*

Further details of the new electronic computing system, the NCR 315, have been announced by the *National Cash Register Company*. It is designed exclusively for business data processing and is being manufactured simultaneously in Britain and the United States. One of its most revolutionary features is RACE, a compact random-access store. *NCR* has designed this new equipment in the light of operational experience with the NCR 304 system, already used by leading American business firms, banks and government departments.

Much of the 315 will be manufactured in Britain by *Elliott Brothers* (*London*) *Ltd.* For the past five years, Elliotts have collaborated with *NCR* in the production and marketing of the NATIONAL-ELLIOTT 405, which pioneered the use in Britain of large-volume magnetic files. Thus the 315 project in Britain is the result of a "classic" decision, taken in the early days of commercial computers, to link the electronic engineering know-how of one firm with the practical business know-how of the other.

A combination of random-access units and high-speed tape units can be provided as a method of "laying off" information in ordered sequences.

Information is fed to the 315 central processor in the form of punched paper tape or punched cards. *NCR* has developed a punched card reader which operates at speeds of up to 2,000 cards per minute—much faster than anything hitherto possible in this field—and there is an alternative unit operating at 400 cards per minute. The paper tape input speed is 1,000 characters per second.

For output, the NCR 315 includes one or more National line-at-a-time printers which could produce invoices, statements and other business documents at speeds of up to 1,200 lines per minute.

Other input and output devices can be placed under the direct control of the 315 central processor, including electronic document sorters using the E13-B magnetic ink characters adopted recently by the London Clearing Banks. The NCR 315 has been designed to accept programs written in COBOL.

The NCR 315 is an exceptionally fast computer and a complete data processing system designed exclusively for business use. It consists of a central processor, a control console with keyboard and monitor printer, and a wide range of peripheral units which, because of their modular design, can be arranged to suit any requirements.

Each peripheral unit has its own power supply and can be fitted on site without engineering work. Therefore the purchaser of a 315 gets what is, in effect, a custom-built system. He can also expand or modify his system if there are subsequent changes in his data processing requirements. The range of peripheral equipment has been specially designed to match the high speed and capacity of the central processor. It includes:

Paper-tape reader.
Punched-card reader.
Document sorter/reader.
Paper-tape punch.
Card punch.
High-speed line printer.
Magnetic-tape memory unit.
Inquiry unit.

There is also a new form of random-access memory, details of which are given below. Up to 16 such units can be coupled to one processor, giving either random or sequential access to more than 128 million decimal digits or 90 million alpha-numeric characters.

The equipment is completely transistorised and uses ferrite cores for storage and other functions. These solid-state devices, together with the advanced methods of construction, are expected to ensure long life, exceptional reliability and low power consumption. Construction tolerances are set for beyond "worst case" conditions of heat, voltage fluctuation and ageing. The logic is very largely built from standard plug-in circuits; for example, only one type of flip-flop circuit is used throughout the processor.

The 315 has a single-level, high-speed internal memory—a semi-linear-select ferrite core store with a basic cycle time of only six microseconds.

The main memory unit may be of any of three capacities: 6,000 digits, 15,000 digits, or 30,000 digits. Up to three additional 30,000-digit memories can be fitted to a machine with a basic 30,000 digit unit—providing immediate access to a maximum of 120,000 digits.

The internal speed of the 315 central processor is higher: here are some examples of operating times:

Two 6-digit numbers are added in 48 microseconds.
Two 6-digit numbers are compared in 48 microseconds.
Two 3-digit numbers are multiplied in 288 microseconds.
Two 6-digit numbers (with like signs) are added to the memory in 48 microseconds.

The above times include access to both the commands and to operands in the core memory, and also the modification of addresses.

The comprehensive order code is designed for business data processing and it provides facilities for over 160 different functions. These include built-in comparison and test facilities, and advanced sub-routine linking and editing facilities.

The internal speed of the 315 has made it possible to provide highly sophisticated coding techniques at relatively low cost. A COBOL translator will be available when the first NCR 315 computers are delivered.

RACE differs radically in design from previous computer memories and it will open up new frontiers for clerical automation. Transactions affecting sales, production, stocks and other business records can be processed in random order as soon as details are received. Not only does this make it possible to maintain up-to-the-minute records: it also eliminates the pre-sorting of computer input data which, with conventional tape decks, is an unavoidable operation tending to detract heavily from the overall speed and economy of electronic data processing.

The RACE memory unit employs Mylar plastic cards on which information is recorded magnetically. The cards are held in removable cartridges, each of which has a capacity of over five million alpha-numeric characters. With the maximum of 16 units coupled to the computer simultaneously, over 84 million characters are immediately available for processing at any moment. Moreover, since the cartridges are interchangeable, the total filing capacity of the system is unlimited.

Although entirely new in conception, the RACE random-access memory is based on thoroughly-tested principles of electronic and mechanical precision engineering. Information is stored magnetically on Mylar plastic cards held in removable magazines. This storage is unusually compact: each card, measuring 3¼ in. wide by 14 in. long, holds 21,700 alpha-numeric characters or 32,550 decimal digits. Each removable magazine contains 256 magnetic cards, giving a total capacity per magazine of over 8 million digits.

Up to 16 RACE units may be simultaneously coupled to one 315 central processor. Magazines can be changed in a matter of seconds; therefore the total filing capacity of the system is virtually unlimited. The average access time is 170 milliseconds, which is shareable after "look-ahead." Re-access time averages 23 milliseconds, and the transfer rate is 150,000 digits per second. The contents of the file can be processed in either random or sequential order.

Trouble-free performance is ensured by various reliability checks. These include an echo check on unit and card selection; selection check for unit number duplication; parity check on each character transmitted; and "write" check (each character written is read immediately afterwards and subjected to a parity check).

Two types of magnetic-tape unit are available. The standard model provides transfer rates of 24,000 and 40,000 characters per second; the high-performance model, transfer rates of 24,000, 40,000 and 60,000 characters per second. Units handle 3,600 ft. reels of ½-inch Mylar tape, the data being stored at densities ranging from 200 to 500 characters per inch. Tapes written at 24,000 characters per second can be used on IBM tape units.

Up to eight such units can be coupled to the central processor. Tape units can also be used in conjunction with the random-access units.

Typical working speeds for peripheral equipment are as follows:

Paper tape (5, 6, 7 or 8 channel) is read at 1,000 characters per second.

Punched cards are read at either 400, or 2,000 cards per minute.

Paper tape output is punched at 120 characters per second.

Cards are punched at either 100 or 250 cards per minute.

The line printer has a normal working speed of 850 lines per minute, but this rises to 1,200 lines per minute when printing is restricted to numerals alone. Various combinations of line printers and card punches (up to maximum of four units) can be directly coupled to the central processor.

Although the 315 is an on-line system, the document register/sorter, high-speed printer, card punch and inquiry unit are "buffered" and can operate off-line after they have been activated by the central processor.

To provide maximum time sharing and working efficiency there is an "interrupt" feature, operating under program control, which automatically interrupts the main program whenever one of the peripheral units is ready to accept further data.

Information for output by line printer, card punch or inquiry unit is transferred to the appropriate buffer at 100,000 characters per second.

Up to 16 inquiry units can be connected to the central processor. Each provides alpha-numeric input and output via a buffer.

Solartron Modern Factory at Chessington

The second stage in the erection of the new air-conditioned factory at Chessington, Surrey, for the *Solartron Laboratory Instruments, Ltd.*, the electronic instrument manufacturing company of the *Solartron Electronic Group*, is now under way.

The administrative block of 25,000 sq. ft., which houses the instrument sales and the international division of Solartron, was occupied early in 1960. Also in this block are the instruments servicing and works training sections, together with some production facilities. The second section of 50,000 sq. ft. now being built will be completed in October 1961, and the third stage—a further expansion of 50,000 sq. ft., for which the Chessington site has available space—is planned to be completed in three years' time. The final factory will be one of the most modern in Britain for the manufacture of electronic instruments and will employ more than 1,000 people.

The training centre, which is incorporated in the new buildings, is claimed to be the most advanced for workers in electronics. A special study has been made of training methods and the result is that operators are working confidently at full production at their benches after an initial training period of six weeks. The training continues from time to time in intensified courses for two years for the creation of an expert operator. In fact, training is integrated with production somewhat as is a University "sandwich" course.

Transistor Service

What does the fast-growing computer industry want from the equally fast-growing transistor industry? A comprehensive survey of mutual problems and their solutions was undertaken in January and February by a newly-formed "Flying Squad" of transistor experts from Newmarket Transistors Limited.

The four-man team (Thomas Towers, Richard Warrington, Thomas Dilley and Bryan le Gry) had been specialising in the application of transistors to computer design and visited nearly a hundred firms on an engineer-to-engineer approach.

The team arranged with computer designers and engineers to demonstrate and discuss its range of low-wattage, fast-switching high-voltage transistors at present being designed and specified for use in basic computers and peripheral equipment.

Newmarket Transistors Limited has had experience in the manufacture of special-quality switching transistors since computers first began to be transistorised, with operational reliability proved by considerable use in Services, Industrial and Commercial computers.

Such close liaison and exchange between engineers is enabling Newmarket to provide a standard, comprehensive range of transistors closely meeting the needs of computer manufacturers.

London's Bus Timetables to be Computer-Compiled?

London may be the first city in the world to operate its buses according to timetables compiled by an electronic computer, if the present rate of progress on automatic timetable compilation is maintained. It should then be possible to produce, quickly, schedules reflecting the changing requirements of passengers.

Members of London Transport's Electronic Data Processing Unit and *EMI Electronics Ltd.* have been jointly investigating the problem for several months. They have succeeded in compiling and printing, on an EMIDEC 1100 computer, in 30 seconds, a timetable for the simplest type of bus route, which would take a schedule compiler at least an hour to produce manually in rough outline.

In the United States of America, computers have been used to collate passenger loading information, and to print out the final documents after the timetable has been compiled mainly by hand. It is known that one other computer manufacturer in the United Kingdom has carried out experiments in crew scheduling for a provincial bus company.*

"We must stress that so far we have only reached the end of the beginning," said a London Transport spokesman, "and much work remains to be done before more complex operating timetables can be compiled by computer. But we are very hopeful that the EMIDEC will enable us to produce schedules and related statistical information, vehicle time cards and inspectors' time books much more quickly and economically than by manual methods.

"It should also be possible to compile timetables more closely in line with the fluctuating needs of users. The computer would also deal with special traffic conditions which arise from time to time, such as during Wimbledon Tennis Tournament and the F.A. Cup Final."

In order to gain an insight into the problem, the simplest type of bus route—from *A* to *B*, without any intermediate turning-points or branches—was taken as a basis, and the logical rules underlying the compilation of a timetable for such a route were determined. From these rules, a detailed computer programme was built up.

The program needs to be written only once, since it will accept variations in specifications for different routes. The computer can then compile the complete timetable for a particular route in ten seconds, and immediately print out the information in as many different forms as are needed. There is an even greater saving in time when producing the subsidiary documents than there is in printing the time schedule.

The next problem is to define the logic and write the computer programs for the more complex types of timetable, comprising several intermediate turning-points, two or more garage allocations, and inter-working requirements where several routes follow the same path over parts of the journeys.

This will be more difficult, but the experience gained so far with EMIDEC will prove valuable by pointing the way to solutions of the more complex problems. It is confidently expected that the gain in speed of schedule compilation will increase as the schedules become more complicated.

* Ferranti Ltd. on a Pegasus with Oxford City Motor Services Ltd.

Pictured here, examining a package of the EMIDEC 1100, *are (left to right) Mr. B. Pitts, E.M.I. Electronics Ltd.; Mr. B. H. Harbour, Member of Executive responsible for Road Operating and Engineering; Mr. G. O. Gallop, Electronic Data Processing Unit; Mr. A. Bull, Member of Executive responsible for Railway Operating and Engineering; Mr. J. Grover, E.M.I. Electronics Ltd.*

PACE Analogue Computers

University College, Swansea, Department of Chemical Engineering, have placed an order with *Electronic Associates Ltd.* of Burgess Hill, Sussex, for a PACE analogue computer of 48 amplifiers. This computer will be the eleventh 0·01% machine to be installed in the United Kingdom and is the first high-accuracy instrument to be purchased by a British University and the first to be used on distillation column and other chemical process problems in this country.

Although such computers are used widely in the US their benefits have not previously been appreciated in British industry outside the nuclear, missile and aircraft fields.

Japan's First Univac II Completion at Philadelphia

The first UNIVAC II electronic computer for Japan was completed at the Philadelphia plant of the *Remington Rand Univac Division* of the *Sperry Rand Corporation* in December 1960. It has been purchased by the Tokyo Electric Power Co. for use in a wide variety of applications—chief of which will be a method of controlling the 30 or more Tokyo metropolitan region power stations and sub-stations of the company. The new, large-scale computer, described as the most advanced ever made for Japan, cost about $2,000,000. Shipment to Japan cost at least another $40,000.

The unit required three 35-foot truck trailers to carry it from the Philadelphia plant to the Mitsui Line pier in Brooklyn, New York, from where it was loaded on to the Mitsui steamer, *Hakone San Maru.*

A crew of seven men flew to Japan to meet the vessel on its arrival at Yokohama and supervise its installation on the sixth floor of the headquarters building of the *Tokyo Electric Power Co.* Because of its size, it had to be lifted on the outside of the building in sections.

With the new UNIVAC II computer a wide variety of data from all electricity stations will be fed into the central office on to a master tape and then the computer will be able to make computations to determine power requirements and power peak loads.

The installation in Tokyo is modelled after highly successful use of a UNIVAC II computer by the *Ontario Hydro-Electric Power Co.* in Ontario, Canada. The press release does not explain why the computer has to be in the city centre on the sixth floor.

Simplified Plug-Board Procedure

The Novano pre-wired plaque, recently developed—and pioneered—in Britain by Novotechnics is an ingenious but inexpensive device to simplify the plug-board procedure of electro-mechanical punched-card tabulating machine systems. The use of the plaque also reduces the number of basic control panels which need to be replugged for each application. The Novano system has been adopted by a number of well-known companies with extensive punched-card installations.

It is manufactured by *Novotechnics* of Jubilee Road, Letchworth, Herts, and it will in future be sold in the United Kingdom exclusively by ICT.

Leo Computer for Standard-Triumph

A LEO II/C computer was installed in December 1960 at the Canley, Coventry, headquarters of *Standard-Triumph International*, the car manufacturers. This is the second LEO to be put into operation in the motor-car industry; it will at first undertake supply, costing and production/stock control. Later, its use will be extended to cover other work.

A Short Brothers Simulator for Atomic Power Stations

An interesting current activity of the *Short Brothers & Harland Ltd.*, Precision Engineering Division, at Castlereagh, Belfast, is the development of a special-purpose analogue computer, which will simulate the behaviour of a complete nuclear power station.

The computer, which has been ordered by the United Kingdom Atomic Energy Authority and will be installed at the Calder Operations School, is a large one and contains 200 computing amplifiers. It will enable a trainee operator to attain—before he goes to work in an actual station—a high degree of proficiency in the control of reactors, including the handling of such emergencies as the development of instability in the pile.

The simulator will comprise a console and five racks of equipment. It will represent a reactor which, for the purpose of simulation, is considered as being split into three zones. The nucleonic and core heat transfer simulation units for each particular zone are mounted in a standard Post Office type rack about 7 feet high. Thus three of the simulator's five racks are identical, an arrangement which has the advantage that simulation of any further splitting of the core would necessitate only the installation of more standard racks.

The fourth and fifth racks house the equipment for reproducing the behaviour of the heat exchangers, steam production and flow, and the generator section. Information will be supplied to the instruments on fuel cartridge radiation, inlet and outlet temperatures of the gas, steam pressures and rate of flow, position of the control rods, turbine speeds, and electrical power output.

A mock reactor control desk similar to those being supplied to new power stations is being designed by the U.K.A.E.A. Research and Development Board for use with the Short simulator. The instruments on the desk will receive their information from the simulator, which will also interpret any control adjustments made by the trainee operator and revise its signals to the desk instruments accordingly.

Thus the new operator will receive his instruction at a control desk which, as far as the evidence of his senses is concerned, is directing the activities of a full-scale nuclear power station.

The control simulator with its removable patch panel is accommodated in the console, which also acts as a junction box for the interconnection of the three reactor zones and the heat exchange turboalternator group. This provides a flexible arrangement in that the addition of further zones involves only the laying of an extra cable up to the console; the original equipment remaining undisturbed. The power units are also housed in this console; they are fully transistorised and dissipate very little heat.

COMPUTER SOCIETIES IN THE NETHERLANDS

The work, equivalent to the *BCS*, is carried out in the Netherlands by two Societies.

(*a*) *Scientific and Mathematical*

The Rekenmachine Genootschap, which is a section of the Mathematical Centre in Amsterdam. The president of this is Professor van Wijngaarden, a well-known visitor to mathematical and computer conferences in the United Kingdom.

(*b*) *Business applications*

The Genootschap Studiecentrum voor Administratieve Automatisering, which is a section of the Netherlands A.D.P. Centre in Amsterdam. Mr. W. B. P. J. Blokhuis is Secretary of the Netherlands Society for Automatic Data Processing and Dr. M. Euwe is Managing Director of the A.D.P. Centre. This Society now has 500 members.

Members of either Society resident in the Netherlands or in overseas territories where the Dutch language is used, may subscribe through their Society office in Amsterdam to *BCS* publications at the following prices:

	Normal Price to subscribers	*Special price to members of a Netherlands Computer Society*	
The Computer Journal (4 issues per year) ..	£2 10 0	£2 0 0	D. fls. 21.20
The Computer Bulletin (4 issues per year) ..	15 0	12 0	D. fls. 6.35
Combined Subscription	£3 5 0	£2 7 6	D. fls. 25.15

Journals and *Bulletins* are mailed direct to subscribers and members.

SOUTHAMPTON BRANCH FORMATION

Numerous keen members in the Southampton area have decided to form a branch of the Society in this area, and an inaugural meeting will be held during the week commencing 10 April.

Will members resident in this area who are willing to support this project please communicate with:—

J. Sharp, Esq.,
I.B.M. British Laboratories,
Hursley,
Nr. Winchester, Hants.

Correction

Bulletin, Volume 4, No. 2, Supplement, page 72, second line, right-hand column:—
"IBM 7070" should read "IBM 705."